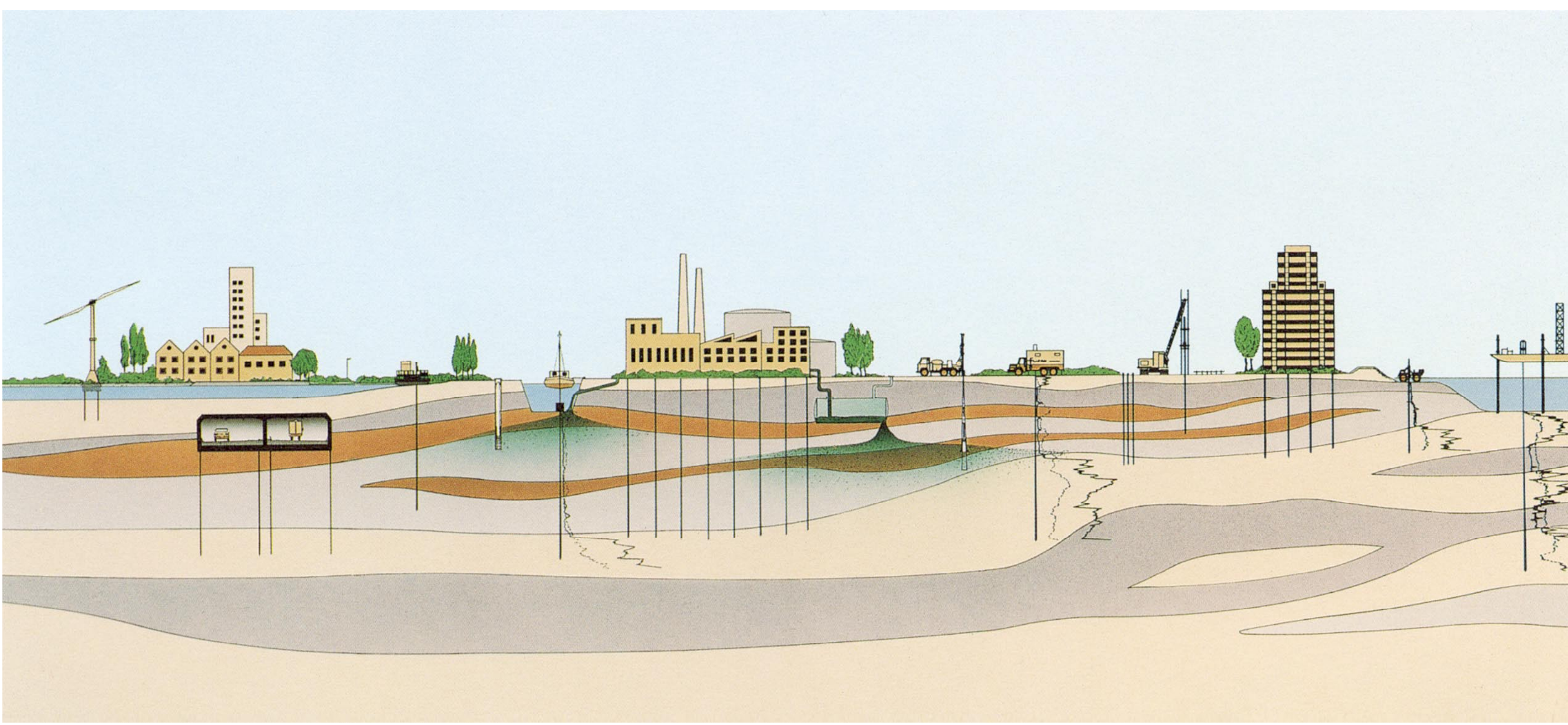
FUGRO WEST, INC.

GEOTECHNICAL STUDY REPORT
DWP RECLAIMED WATER PIPELINE
PORT OF LOS ANGELES

Prepared for:
CITY OF LOS ANGELES HARBOR DEPARTMENT

June 1997



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June 19, 1997
Project No. 96-42-1217

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Attention: Mr. Todd Le

Geotechnical Study Report
DWP Reclaimed Water Pipeline
Port of Los Angeles

Fugro is pleased to submit our geotechnical report for the proposed Department of Water and Power (DWP) reclaimed water pipeline at the Port of Los Angeles (POLA). The proposed alignment will cross under the Turning Basin between Berth 150 in the Unocal Marine Terminal and Berth 225 in the Yusen Terminal. This study was completed in general accordance with Fugro's revised Proposal Addendum 2 (dated February 27, 1997), and was authorized as Task V of LAHD Agreement No. 1948 for geotechnical and environmental services for the POLA Main Channel Deepening Program (dated March 26, 1997). A draft report was provided previously for the DWP and POLA review.

Field exploration and other related activities described in this report were undertaken in conjunction with field exploration for the Main Channel Deepening Program geotechnical and environmental studies and the associated investigation for the relocation of the Department of Public Works (DPW) Fries Avenue force main across the Los Angeles Inner Harbor East Channel.

Our report provides geotechnical recommendations for the design of the proposed pipeline. The main text of this report includes our description of the site and subsurface conditions, and provides the results of our analyses together with our conclusions and recommendations. Illustrations that support our summary of conditions and design recommendations follow the main text. The factual data and results of our subsurface explorations and laboratory testing are included in appendices to this report.

On behalf of Fugro, we appreciate the opportunity to provide the enclosed report to the City of Los Angeles Harbor Department and Department of Water and Power. Please call if we can answer any questions or provide additional information.

Sincerely,

FUGRO WEST, INC.

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INTRODUCTION

Project Description

The Los Angeles Harbor Department (LAHD) is currently planning to deepen the navigation channels of the Port of Los Angeles (POLA) Inner Harbor. Concurrently, the City of Los Angeles Department of Water and Power (DWP) is evaluating the possibility of installing a 36-inch-diameter reclaimed water pipeline that will pass below the Turning Basin of the POLA Inner Harbor. It is anticipated that the construction of the DWP reclaimed water pipeline across the Turning Basin would be included in the POLA Main Channel Deepening construction.

Plate 1 - Vicinity Map, shows the general location of the Turning Basin and the project site relative to local landmarks. The proposed alignment of the DWP reclaimed water pipeline is shown on Plate 2 - Exploration and Cross Section Location Map. As shown on Plate 2, the proposed channel crossing route will extend from the Unocal tank farm near Berth 150 to Berth 225 of the Yusen Container Terminal, near the eastern abutment of the Vincent Thomas Bridge. The pipeline route across the Turning Basin will be about 2,400 feet long.

Our understanding of the pipeline alignment is on the basis of the coordinates provided to us by Mr. Victor Soto of the DWP in his fax transmittal dated April 17, 1997. A schematic cross section showing conditions along the alignment of the pipeline is presented on Plate 3 - Pipeline Profile. As shown on Plate 3, the base of the pipeline beneath the Turning Basin will be at approximately elevation (El.) -69 feet[1]. Slope inclinations of approximately 1½H:1V (horizontal:vertical) at Berth 225 to approximately 3H:1V at Berth 150 are proposed for the transition sections of the pipeline beneath the navigation channel slopes.

We understand that the underwater portions of the pipeline will be constructed using open-cut trenching. The excavation to construct the trench should require dredging of about 100,000 to 150,000 cubic yards of sediment. That volume assumes that the POLA Channel Deepening project will be completed prior to the start of this project. Disposal sites being considered for these sediments include: a) upland areas, b) ocean disposal in LA-2 or LA-3, c) placement in the POLA Cabrillo Shallow Water Habitat Extension or other Confined Aquatic Disposal (CAD) sites, or d) placement into Stage 2 of the Pier 400 hydraulic landfill.

At the pipeline landfalls, pipe-ramming techniques are planned to advance the pipe between the land and channel crossing sections. Pipe-ramming will be required between the pile foundations of the existing wharf at Berth 225. At the northern landfall near the Unocal tank farm, the pipeline is planned to be within the limits of the Harbor Belt Line Railroad easement.

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[1] All elevations presented in this report are referenced to mean lower low water (MLLW).

Authorization

On behalf of the DWP, the LAHD included the following add-ons to the geotechnical and environmental subsurface investigations for the POLA Main Channel Deepening Program and associated City of Los Angeles Department of Public Works (DPW) Fries Avenue force main projects:

- The overwater and land exploration
- Geotechnical and environmental testing
- The geotechnical evaluation of the navigation channel crossing for the DWP reclaimed water pipeline

The results of those efforts for the DWP project are being provided in two reports that include: 1) this geotechnical study report prepared by Fugro, and 2) the environmental sediment evaluation report prepared by Kinnetic Laboratories, Inc., under subcontract to Fugro.

The geotechnical and environmental sediment studies for the DWP reclaimed pipeline channel crossing were conducted in general accordance with Fugro's revised Proposal Addendum 2, dated February 27, 1997. The DWP work scope was authorized as Task V of LAHD Agreement No. 1948 for geotechnical and environmental services for the POLA Main Channel Deepening Program dated March 26, 1997.

Purpose and Scope

Purpose. The purpose of this geotechnical study was to explore subsurface conditions at the project site and to provide geotechnical data and recommendations for the design of the DWP pipeline. This report presents recommendations for the support and backfill of the pipeline. Recommendations also are presented relative to the stability of trench side-slopes for underwater portions of the pipeline, and pipe-ramming at the pipeline landfalls. The geotechnical study, reported herein, is being provided to the LAHD and the DWP to be used during the development of plans and specifications for the project.

Scope. The geotechnical scope of work for the reclaimed water pipeline channel crossing and landfalls investigation includes:

- Nearshore environmental vibrocore sampling with geotechnical logging of vibrocores;
- Overwater geotechnical borings with environmental sampling;
- Onshore geotechnical borings;
- Geotechnical laboratory testing; and

- Preparation of this geotechnical report describing the subsurface materials along the reclaimed water pipeline channel crossing route and landfalls, their geotechnical characteristics, and providing geotechnical design recommendations.

The investigation as described herein does not include investigation or evaluation of the subsurface conditions for the portions of the pipeline route that are onshore of the pipe-ramming pits at the channel crossing landfalls.

Report Organization

The geotechnical study report for the project includes an *Introduction* section followed by discussions relative to the *Sources of Subsurface and Geotechnical Data*. The next section includes summaries of *Interpreted Stratigraphic Conditions* in the vicinity of the pipeline. The final section presents and discusses the *Recommendations for Pipeline Design*. Illustrations and maps that portray site and subsurface conditions follow the report text.

A discussion of the methods used together with a presentation of the factual field exploration and geotechnical laboratory test data developed during our investigation are provided in Appendices A through C - Field Exploration Data, Laboratory Test Results, and Additional Field Exploration Data, respectively.

Limitations

This geotechnical study has been prepared for the LAHD and the DWP solely for planning, design, and other considerations associated with the DWP reclaimed water pipeline project channel crossing across the Inner Harbor Turning Basin. The applicability of this report is specifically limited to current conditions and considerations for the proposed pipeline. Data, results, evaluations, conclusions, and recommendations contained in this report are directed at and intended to be utilized within the scope of work contained in LAHD Agreement No. 1948 and Fugro's February 27, 1997, revised work scope and fee proposal. This report is not intended to be used for any other purposes.

In performing our professional services, we have used that degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical engineers currently practicing in this or similar localities. No other warranty, express or implied, is made as to the professional advice included in this report. Fugro West, Inc., makes no claim or representation concerning any activity or conditions falling outside the specified purposes to which this report is directed.

The interpretation of general subsurface conditions is based on subsurface conditions observed at exploration locations only. The information interpreted from those explorations has been used as a basis for our interpretations. Conditions may vary at locations not investigated by our explorations. Subsurface conditions also may change with time due to either natural phenomena or people's activities. We note that any statements, or absence of statements, in this geotechnical report regarding odors, unusual or suspicious items, or conditions observed are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/toxic assessment.

Users of this report should recognize that the construction process is an integral design component with respect to the geotechnical aspects of a project, and that geotechnical engineering is an inexact science due to the variability of natural and man-induced processes that can produce unanticipated or changed conditions. Proper geotechnical observation and testing during construction thus are imperative in allowing the geotechnical engineer the opportunity to verify assumptions made during the design process. Therefore, we recommend that Fugro be retained during construction to observe compliance with the design concepts and geotechnical recommendations, and to allow design changes in the event that subsurface conditions or methods of construction differ from those anticipated.

SOURCES OF SUBSURFACE AND GEOTECHNICAL DATA

Introduction

Subsurface information used for this study were derived from: 1) various historic references showing the predevelopment morphology of the area; 2) information provided by the LAHD from the POLA files; 3) field exploration conducted by Fugro in the Turning Basin during the Phase 1 and Phase 2 investigations (Summer 1996 and Spring 1997, respectively) for the POLA Main Channel Deepening Program; and 4) the field explorations performed specifically along the pipeline alignment for the DWP project.

Predevelopment Morphology

The existing configuration of Terminal Island and the POLA Inner Harbor were created by various episodes of land reclamation, dredging, and associated construction of Port facilities. Those land reclamation projects were initiated in the early 1900s, continued at discrete intervals through the 20th century, and are continuing today.

The history of the project region was developed by reviewing historical photographs, aerial photographs, publications, and maps. The following table lists some of the more significant sources and maps.

Source	Corresponding Reference
Publications	
Outwest (article by Fries)	Fries (1907)
Los Angeles-Long Beach Harbor Areas Cultural Resources Survey, Los Angeles County, California	Weinman and Stickel (1978)
The Ports of Los Angeles, Long Beach, and Port Hueneme, California, Port Series No. 28	USACE (1985)
Maps	
Point Fermin Eastward to San Gabriel River	U.S. Coast Survey (1859)
San Pedro Harbor	Coast and Geodetic Study (1908)

Data From POLA Construction Drawings

Typical cross sections of the dikes and wharves at the pipeline landfalls along the north and southeast boundaries of the Turning Basin were obtained from the POLA files. A cross section through the dike at Berth 149, along the northern limit of the Turning Basin, is shown on a 1955 drawing provided to us by POLA (1955). Although this cross section is to the north and west of the proposed pipeline alignment, the dike section shown on the drawing could be similar to that in the vicinity of the northern pipeline landfall. The Berth 149 cross section shows the dike to have a slope inclination of approximately 1-1/2H:1V and to be protected by up to 8 feet of riprap.

A 1963 drawing showing the dike and wharf section in the vicinity of Berths 218 through 225 (POLA, 1963), along the southeastern limit of the Turning Basin, was provided to us by POLA and is reproduced on Plate 4 - Design Wharf Cross Section, Berth 225. As shown on Plate 4, the existing mudline at the time of wharf construction reportedly was approximately El. -32 feet at the pierhead line, and sloped upwards at inclinations of approximately 5H:1V. The existing ground surface is shown to be at approximately El. -18 feet at the shoreward limit of the wharf. The drawing includes a construction note indicating that the toe of the existing slope was to be trimmed and the channel dredged to El. -35 feet.

The cross section for Berths 218 through 225 shows a dike with a finished slope inclination of 1-3/8H:1V. The drawing shows that a "quarry muck toe" was to be constructed between the existing ground surface and the planned finished grade to El. -19 feet. Above the "quarry muck toe", the slope protection was shown to consist of approximately 3 feet of riprap. Additionally, "quarry muck" was to be placed below the riprap and above a 2H:1V line that projected up from the limits of dredging. Within the limits of the wharf, "select fill" materials were to be placed between the quarry muck and the then existing ground surface. Although the then existing ground surface in the backland areas is not shown on the drawing, a note indicates that compacted "select fill" was to be placed to result in finished grade elevations of approximately El. +16 feet in backland areas.

Data from Main Channel Deepening Program

Fugro has conducted numerous vibrocores and tethered "Seascout" Cone Penetration Test (CPT) soundings to provide information to guide the planning and design of the POLA Main Channel Deepening Program. Those explorations and the associated laboratory testing were conducted in two phases. Phase 1 was completed in late summer of 1996. Phase 2 exploration was conducted in Spring 1997, concurrently with the exploration for the DWP pipeline.

The data from the Main Channel Deepening Program explorations are within the limits of navigation channels that will be deepened, and are generally representative of stratigraphic conditions above an elevation of about -55 feet. Consequently the data are primarily applicable to the geotechnical and environmental characterization of the sediments that will be excavated during pipeline construction and to the evaluation of the stability of cut slopes.

The locations of those Main Channel Deepening Program explorations in the Turning Basin are shown on Plate 2. Vibrocore logs and CPT sounding traces for explorations performed within about 500 feet of the proposed DWP pipeline alignment are presented in Appendix C. A further description of the methods used to obtain those data and the testing results are provided in Fugro's Report No. 96-42-1213, dated December 18, 1996 (Fugro, 1996) and Report No. 96-42-1215, in preparation.

Field Exploration and Laboratory Testing for the DWP Pipeline Project

Scope of Exploration. The subsurface exploration conducted specifically for the DWP reclaimed water pipeline included the advancement of seven borings (designated as DWP-B1 through DWP-B7) and seven vibrocores (designated as DWP-V1 through DWP-V7). Our field investigation program was intended to characterize subsurface conditions in the project vicinity and to provide samples for both geotechnical and environmental laboratory testing.

The seven borings included four borings (DWP-B2 through DWP-B5) drilled overwater in the Turning Basin, two land borings (DWP-B1 and DWP-B7) drilled near the planned pipeline landfall locations, and one boring (DWP-B6) drilled through the wharf at Berth 225. The seven vibrocores included three vibrocores (DWP-V1 through DWP-V3) between the edge of the navigation channel and the toe of the Berth 150 dike, and four vibrocores (DWP-V4 through DWP-V7) between the edge of the navigation channel and the toe of the dike at Berth 225. The locations of the borings and vibrocores are shown on Plate 2.

The seven DWP vibrocores were collected to characterize the nearshore sediments between the shoreline and the edges of the navigation channels, and to recover samples for environmental analyses outside of the area sampled for the POLA Main Channel Deepening Program. Data from the boring program were used for geotechnical and environmental characterization of materials at depths greater than the maximum depths investigated by the vibrocores and CPTs. Additionally, sampling techniques used in the borings provided higher quality samples than those obtained with the vibrocores for the evaluation of the density, strength, and compressibility of the sediments above and below the pipeline.

A summary of the dates of exploration, location, and surface elevation for each boring and vibrocore location is provided on Plate A-1 in Appendix A. The surveyed coordinates conform with California Coordinate System Zone 7.

A description of the exploration equipment and operations is summarized below and provided in more detail in Appendix A. Logs of the borings and vibrocores are similarly presented in Appendix A. Boring logs are provided on Plates A-2 through A-8, vibrocore logs are shown on Plates A-9 through A-11, and a key to many of the terms and symbols used on the boring logs is included as Plate A-12. Similarly, a description and the results of the laboratory soil testing program are provided in Appendix B.

Borings. The seven borings drilled for the DWP reclaimed water pipeline were drilled between April 22 and May 2, 1997. The execution of the boring program was conducted together with the execution of the boring program for the proposed DPW Fries Avenue force main relocation across the Inner Harbor East Channel. The sequence of drilling included the completion of all overwater borings for both projects followed by the advancement of the land borings for both projects. The specific sequence of the borings was based on the requirements imposed by navigation access in the channels and terminal operations in the onshore areas.

The borings were excavated using a truck-mounted, Failing 1500 rotary drill rig operated by Pitcher Drilling Company of Palo Alto, California. The borings were advanced using wet rotary drilling methods. The four overwater borings in the navigation channel were drilled from a 55-foot by 24-foot barge that was anchored over the boring location using a four-point anchor spread. The boring drilled through the wharf deck at Berth 225 was advanced by first coring through the wharf and then setting a casing down to the slope underlying the wharf.

The two onshore borings (DWP-B1 and DWP-B7) were sampled to a maximum depth of approximately 31 feet, and to a minimum elevation of -19 feet. These borings were sampled at about 5-foot intervals. The four overwater, navigation channel borings (DWP-B2 through DWP-B5) were sampled to a depth of between 41 and 66 feet below the existing mudline. The terminal elevation for those borings ranged between about El. -93 feet and El. -102 feet. The overwater borings were sampled at approximately 3-foot intervals to depths corresponding to the proposed bottom of pipeline elevation and at approximately 5-foot intervals at greater depths. The wharf boring (DWP-B6) was drilled to a penetration of about 54 feet which corresponded to a terminal elevation of about El. -71 feet.

Vibrocore Explorations. A total of seven vibrocores were performed along the alignment of the pipeline on April 9 and April 25, 1997. As shown on Plate 3, the vibrocores were located beyond the edges of the navigation channel that were sampled as a part of the POLA Main Channel Deepening Project. Three vibrocores (DWP-V1 through DWP-V3) were located in the vicinity of the toe of the dike along the shore of the Unocal property to the north of the navigation channel, and four vibrocores (DWP-V4 through DWP-V7) were located near the toe of the dike near Berth 225. The vibrocores were advanced to depths of approximately 9.5 to 19 feet below the existing mudline. Terminal elevations for the vibrocores ranged from about El. -54 to -56 feet.

The vibrocore sampling activities were conducted from the *R/V Hood*, a dedicated sampling vessel equipped for vibrocore sampling and operated by Kinnetic Laboratories, Inc. Descriptions of the recovered sediments and subsamples for geotechnical testing were collected by a Fugro geologist or engineer. Subsamples for environmental processing and testing were collected by Kinnetic personnel.

Geotechnical Laboratory Testing. Geotechnical tests were performed in Fugro's Ventura laboratory on samples retrieved from the boring and vibrocore locations. The purpose of the geotechnical testing was to:

- Classify and characterize sampled subsurface materials;
- Evaluate the existing in situ conditions; and
- Develop relevant strength and compressibility properties of specified subsurface materials.

A description of the laboratory testing program, test methods, and numbers of tests conducted is provided in Appendix B. Factual laboratory test results also are tabulated or presented graphically in Appendix B. In addition, various laboratory test results tabulated versus depth on the individual boring and vibrocore logs are presented in Appendix A.

INTERPRETED STRATIGRAPHIC CONDITIONS

Predevelopment Morphology

Prior to development, the project area was occupied by Wilmington Lagoon and Rattlesnake Islands. Wilmington Lagoon actually consisted of numerous channels, wetlands, and several small islands, including Smith Island and Morman Island. Wilmington Lagoon was separated from the Pacific Ocean by Rattlesnake Island, a 700- to 1,000-foot-wide barrier beach.

Although the predevelopment lagoon conditions have been either removed during prior dredging or buried by fill, there is ample evidence in the subsurface data that the complexity of conditions shown on the old morphology maps is also present in the stratigraphic sequence in the Holocene sediments that underlie the lagoon. The location of the project area, exploration locations, and the pipeline alignment relative to predevelopment morphology shown on the Coast and Geodetic Study (1908) map is illustrated on Plate 5 - Predevelopment Morphology. As shown on Plate 5, the DWP pipeline alignment crosses the former location of Wilmington Lagoon between the former locations of Smith Island and Morman Island. Prior to development, this area of the lagoon was extensively channeled and several channel locations cross the proposed pipeline alignment.

As shown on Plate 5, the southeastern landfall of the DWP pipeline is located near the western end of Rattlesnake Island. The northern landfall near the Unocal terminal is shown to be in the vicinity of one of the small islands within Wilmington Lagoon. The morphology shown within the limits of the Turning Basin appears complex. As indicated in Fugro (1996), the complexity appears to be associated with the merging of several old paleochannels, the presence of localized islands, and movement along the Palos Verdes fault (McNeilan et al., 1996).

Proximity of Palos Verdes Fault and Potential Fault Rupture

The POLA is located within a region of active tectonics and seismicity. The nearest known active regional fault is the Palos Verdes fault. Recent studies performed for the LAHD (Fugro, 1994; McNeilan et al., 1996) on the Palos Verdes fault substantiate that the Palos Verdes fault is an active fault with documented Holocene activity. Mapping of a dated paleochannel offset across the fault (in the Los Angeles Outer Harbor) was used to constrain the Holocene slip rate of the fault to about 3 millimeters per year (mm/yr), one of the largest documented slip rates within the Los Angles Basin. The study interprets that the active trace of the fault strikes northwest-southeast (approximately parallel to the proposed DWP pipeline alignment) and passes below the Vincent Thomas Bridge, about 800 to 1,000 feet southwest of the proposed pipeline alignment.

Other more recent studies for the seismic retrofit of the Vincent Thomas Bridge (CDMG, 1996) suggest an approximately 2,400- to 2,800-foot-wide fault zone with several possibly active fault strands crossing the POLA navigation channel. The northeastern limit of the interpreted zone of faulting and one of the two most pronounced fault traces, as mapped by CDMG, correlate with the active fault trace as interpreted by Fugro (1994) and McNeilan et al. (1996).

Survey maps (U.S. Coast Survey, 1859; Coast and Geodetic Society, 1908) that show the predevelopment morphology in the San Pedro Harbor area document the presence of a paleochannel that appears to correlate with the interpreted trace of the Palos Verdes fault. The alignment of the paleochannel appears to be fault controlled. Also shown on those maps are paleochannels to the northeast of the mapped trace of the fault, including a channel that appears to approximately coincide with the alignment of the pipeline. If these channels are also fault controlled, there is a potential for the alignment of these channels to coincide with secondary strands of the Palos Verdes fault.

On the basis of the proximity of the mapped trace of the Palos Verdes fault and the potential for strands of the fault along the proposed alignment of the pipeline, we estimate that there is a potential for fault rupture in the vicinity of the pipeline during an earthquake on the Palos Verdes fault. Further evaluation of seismicity in the project vicinity and impacts of fault rupture are outside the scope of the present study.

Channel Bathymetry

Water depths measured at the exploration locations along the proposed reclaimed water pipeline alignment indicate that the bathymetry in the existing Turning Basin is typically between about El. -45 feet and El. -56 feet. The hydrographic survey chart provided by POLA indicates that the side slopes rise at an inclination of between 1-3/8H:1V and 2-1/2H:1V along the sides of the existing navigation channel. The bathymetry at the toe of the dikes bordering the Turning Basin are between about El. -35 feet and El. -45 feet.

Basis of Stratigraphic Interpretation and Potential Subsurface Variability

Fugro's interpretation of stratigraphic conditions (presented in the following paragraphs), is primarily based on boring, vibrocore, CPT soundings, and laboratory test results generated during our field exploration and laboratory testing phases of this project, and the investigations for the POLA Main Channel Deepening Program. The information from those explorations has been used as the basis for our analyses, evaluations, and recommendations.

Those explorations suggest that the conditions underlying the site are variable. The subsequent descriptions of subsurface conditions are generalized descriptions of conditions encountered at the various exploration locations. The history of faulting, dredging, and land reclamation in the project vicinity is complex. Thus, it should be recognized that conditions may vary at locations not investigated by our borings, vibrocores, or CPTs. If variations become evident before or during construction, re-evaluation of our assessments and the recommendations presented herein may be necessary.

Pipeline Location Relative to Main Channel Deepening Program Dredge Elements

The proposed alignment of the DWP reclaimed water pipeline generally corresponds to the transition between two different planned dredge elements of the POLA Main Channel Deepening Program: 1) dredge element FG-1 to the southwest of the pipeline alignment, and 2) dredge element CG-4 to the northeast of the pipeline alignment.

As discussed in Fugro (1996), the dredge elements were defined to differentiate between areas underlain by primarily different types of sediments within the planned dredge depth down to El. -52 feet. Whereas fine-grained silt and clay sediments are interpreted to predominate within the planned dredge depth to the southwest of the proposed pipeline alignment (in dredge element FG-1), coarse-grained sands are anticipated to predominate to the northeast of the pipeline alignment (in dredge element CG-4). As discussed in Fugro (1996), the occurrence of fine-grained sediments to the southwest of the proposed pipeline alignment likely results from the presence of a large clay-filled paleochannel that crosses the POLA Main Channel beneath the Vincent Thomas Bridge.

As described subsequently, the proposed DWP pipeline alignment appears to generally cross the Turning Basin at the edge of the CG-4 dredge element and, therefore, is underlain by primarily sand within the depth interval down to about El. -52 feet. Evidence of fine-grained sediments such as those predominating in the adjacent FG-1 dredge element area, however, are locally present within the upper elevation of the proposed pipeline cut in the southern portion of alignment across the Turning Basin. The proximity of the proposed pipeline alignment to the interpreted dredge element boundary implies that significant changes in sediment type may occur within short distances to the southwest of the planned pipeline alignment.

Stratigraphy

The materials encountered beneath the project site may be divided into the following categories:

- Artificial fill, including quarry muck and riprap
- Harbor bottom sediments
- Holocene deposits

Each of these categories of material is discussed in the following paragraphs. To assist in our interpretation and discussion of the stratigraphic conditions at the site, a subsurface cross section was constructed along the alignment of the pipeline and is shown on Plate 6 - Subsurface Cross Section DWPA-DWPA'. In addition, a second cross section (without vertical exaggeration) at the Berth 225 shoreline is shown on Plate 7 - Subsurface Cross Section DWPB-DWPB'. A key to the symbols used on the cross section is provided on Plate 8. Standard Penetration Test (SPT) N-values (uncorrected for overburden, SPT hammer energy, or fines contents) are tabulated on the cross sections. Also, approximate SPT N-values for driven California liner samplers are shown on the cross sections in red and appear as <xx>. The approximate N-values were obtained by dividing the California liner sampler blow count by 1.6.

Artificial Fill

Fill was encountered in the onshore borings (DWP-B1 and DWP-B7) and the boring (DWP-B6) drilled from the wharf at Berth 225. The fill is typically composed of sandy materials with between 10 and 30 percent fines. The fills include variable amounts and types of oversize material and are likely associated with land reclamation projects and the construction of Port facilities. The interpreted thickness of fill materials is shown on Plate 6.

As shown on Plate 6, the interpreted fill thickness is approximately 10 feet (to a depth of approximately El. +2 feet) in boring DWP-B1 at the northern landfall of the pipeline. As encountered in that boring, the fill materials generally appear to consist of fine to medium sand with varying amounts of silt, scattered gravel, and shell fragments. Measured SPT N-values range from 26 to 43 and the fill is judged to be generally dense in consistency.

The interpreted fill thickness is approximately 15 feet (to a depth of approximately El. +1 feet) in boring DWP-B7 at the southern landfall of the pipeline. As encountered in the boring, fill materials generally consist of silty fine to coarse sand, with scattered shell fragments and wood debris. Measured SPT N-values range from 10 to 24 and the fill is judged to be generally medium dense in consistency. The pavement section at the exploration location consisted of approximately 4 inches of asphalt concrete over 6 inches of aggregate base materials.

Approximately 4 feet of fill (to a depth of approximately El. -22 feet) were interpreted to be present below the mudline at the location of boring DWP-B6 excavated through the dike at Berth 225. As encountered in the boring, the fill materials consist of fine to coarse gravel (quarry run materials?) over clayey sand to sandy clay with about 50 percent fines. A description of the fill materials as shown on construction plans for the dikes in the vicinity of the landfalls of the pipeline was presented in the previous section.

Harbor Bottom Sediments

Several existing data sources (e.g., Fugro, 1996; USACE, 1980; CH2M Hill, 1984; HLA, 1987; USACE, 1995) provide information relative to the occurrence and thickness of harbor bottom sediments (also referred to as surface sediments, muck, or bay mud) within the Inner Harbor. Much of the "surface sediments" identified by the USACE (1980) were subsequently removed when the Inner Harbor was deepened to El. -45 feet in 1981 to 1983. Thus, any harbor bottom sediments encountered within the limits of the existing waterways have likely been deposited since 1981 to 1983, or consists of sediment loosened by the early 1980s' hydraulic dredging. However, the harbor bottom sediments along the edges of the waterways could pre-date the 1981 to 1983 dredging program.

Harbor bottom sediments were encountered in boring DWP-B2 and in vibrocore samples DWP-V1 through V7. These exploration locations were in near-shore areas that are outside the limits of the primary navigation channels in the project area. At the exploration locations to the north of the Turning Basin, the thickness of harbor bottom sediments ranged from 2 to 6 feet and were encountered between El. -36 feet and El. -45 feet. At exploration locations to the south of the Turning Basin, the thickness of harbor bottom sediments ranged from 3 to 6 feet and were encountered between approximately El. -36 feet and El. -52 feet.

In general, the thickness of harbor bottom sediments decreased towards the center of the navigation channels and increased towards the shoreline. Harbor bottom sediments were not encountered in overwater borings DWP-B3 through DWP-B5, which are located within the limits of channels that are frequently traveled and have recently been dredged.

Based on the CPT and vibrocore data, it appears that the harbor bottom sediments primarily consist of very soft to soft fine-grained sediments with a lesser amount of coarse-grained sediments. Grain size testing indicates that the percentage of sand is typically less than about 30 to 45 percent, but occasionally is in excess of 60 to 70 percent. The materials are primarily classified as sandy silt and sandy clay, and occasionally as silty fine sand and silt with sand. Atterberg limits were performed on several samples of harbor bottom sediments. The Atterberg data plot near the A-line on the plasticity chart, with measured liquid limits ranging from about 32 to 44 percent, and plasticity indices between about 12 and 20 percent. Moistures contents range from about 45 to 75 percent. Laboratory density measurements on samples recovered from boring DWP-B2 indicate that the unit dry density of the harbor bottom sediments ranges from about 68 to 75 pounds per cubic foot (pcf).

Holocene Deposits

Holocene sediments were encountered below the artificial fill materials in the onshore borings and either at the harbor bottom or below the harbor bottom sediments in the overwater borings and vibrocores. The Holocene sediments (which were deposited throughout San Pedro Bay prior to the development of POLA) likely consist of marine, alluvial, and estuarine backwater deposits. These deposits were encountered to the maximum depth explored, approximately 66 feet below the existing mudline (El. -106 feet) in boring DWP-B2. The Holocene deposits are subdivided into three strata for descriptive purposes: 1) disturbed surface Holocene deposits, 2) upper Holocene deposits, and 3) lower Holocene deposits.

Disturbed Surface Holocene Deposits. Based on the CPT and vibrocore data acquired during this project and the Main Channel Deepening Program, near-surface Holocene sediments within the limits of the navigational channels are considered to be disturbed. The disturbed deposits encountered in boring DWP-B5 consist of Holocene sediments that were agitated, suspended, and/or redeposited during the hydraulic dredging for the 1981 to 1983 Harbor Deepening Project. The disturbed deposits are typically about 2 to 4 feet thick and generally consist of the same sediment types as the underlying undisturbed deposits.

Our interpretation of the available data indicates that the disturbed deposits are generally thicker and more extensive in areas underlain by coarse-grained sediments (i.e., sand) as compared to areas underlain by fine-grained sediments (i.e., silt and clay). In comparison to the underlying undisturbed deposits, the disturbed deposits typically: a) are a slightly darker color, b) have a distinctly lower cone point resistance, and c) contain more shells and shell fragments. The interface between the disturbed and undisturbed sediments is occasionally marked by a shell hash layer and/or a significant increase in cone point resistance, and typically correlates to elevations of between about El. -50 feet and El. -55 feet.

Upper Holocene Deposits. Undisturbed Holocene sediments were encountered: a) below the zone of disturbed Holocene sediments at locations within the dredged portions of navigation channels, b) below harbor bottom sediments outside the recently dredged areas, and c) below the artificial fill materials placed onshore and along the dike alignments. As shown on Plate 6, these sediments were generally encountered down to depths of about El. -58 to -72 feet.

In the onshore borings, the upper 10 to 15 feet of Holocene deposits consist of silty fine sand and fine sand. Above about El. -10 to -15 feet at the pipeline landfalls, the measured SPT N-values are 9 to 17 and the sands are judged to be loose to medium dense. These sediments probably consist of recent sediment deposited in the lagoon channels prior to development of the harbor area, although they also may be fill sands placed below water during the early stages of Port development.

The remainder of the upper Holocene sediments encountered in our borings generally consists of sands with occasional clay and silt layers. Below about El. -10 to -15 feet, the measured SPT N-values in the coarse-grained materials encountered within the upper Holocene deposits typically range from about 20 to 36 and the sediments are judged to be typically medium dense to dense. Cone point resistances in these sands typically range from 150 to 350 tons per square foot (tsf). That range of cone point resistances correlates to relative densities (using Baldi et al. [1982, 1986] relationships) in excess of about 75 to 90 percent and suggests that the undisturbed deposits may be described as dense to very dense, with occasional medium dense zones. Fine-grained layers are generally stiff to very stiff.

The majority of the coarse-grained materials are poorly-graded fine sand and silty fine sand with a mean grain size (d_{50}) of between 0.1 and 0.2 millimeters (mm). While most of the deposit consists of poorly-graded fine sands, a layer of well-graded fine to coarse sand and silty sand with a mean grain size of between 0.5 and 2 mm was encountered in borings DWP-B4 and

DWP-B5. This well-graded layer has an interpreted thickness of up to 10 feet and was generally encountered between El. -58 feet and El. -68 feet. The unit dry density of the upper Holocene granular deposits typically ranges from about 87 to 116 pcf.

Along part of the southern portion of the pipeline alignment under the Turning Basin, the upper Holocene deposits include a 3- to 6-foot clay layer, which appears to be continuous between sounding CPT-37 and boring DWP-B5 between about El. -54 feet and El. -60 feet. As discussed previously, this clay layer is interpreted to be the edge of a large clay-filled paleochannel that crosses the POLA Main Channel beneath the Vincent Thomas Bridge and then extends across the southwestern half of the Turning Basin. Atterberg limits tests on several fine-grained samples indicate a liquid limit of about 37 to 69 percent and a plasticity index of about 20 to 49 percent. The top of the paleochannel layer is firm to stiff in consistency, while the deeper portion of the paleochannel clay and other clay layers within the sand deposits appear to be desiccated and are more typically very stiff to hard.

Lower Holocene Deposits. Holocene sediments below approximately El. -65 to -70 feet consist of very dense granular materials with occasional very stiff to hard fine-grained layers.

These sediments are predominantly composed of poorly-graded silty fine sands and fine sand with silts. Measured SPT N-values generally exceed 50. Laboratory density measurements on samples recovered from the borings indicate that the unit dry density of the lower Holocene deposits ranges from about 93 to 113 pcf. Sieve analyses indicate that the lower Holocene deposits contain about 5 to 25 percent fines. A sample recovered from boring DWP-B5 had a d_{50} of approximately 0.15 mm.

A layer of very stiff to hard sandy clay was encountered below El. -80 feet in borings DWP-B2 through DWP-B4. This layer was approximately 6 feet thick in DWP-B2 and was encountered in the last 1 to 3 feet of borings DWP-B3 and DWP-B4. Atterberg limits tests indicate a liquid limit of about 43 to 46 percent and a plasticity index of about 16 to 19 percent. Sandy clay to clayey sand was also encountered below about El. -80 feet in boring DWP-B5. Similar materials were encountered by L.T. Evans (1961) in the foundation investigation for the Port facilities between Berths 218 and 224. Borings 7 through 10 of that study were located in the general vicinity of the southern DWP pipeline landfall and reportedly encountered up to 4 feet of silty clay and sandy clay at depths of between El. -84 feet and El. -90 feet.

Strength Properties of Granular Material

CPT tip resistances and SPT N-values typically suggest that the sand layers within the upper Holocene deposits and fill are typically medium dense to dense with loose layers above El. -15 feet. Empirical correlation based on those data suggests that the angle of internal friction in the silty sand and sand layers typically varies from 30 degrees to in excess of 35 degrees. Direct shear tests performed on samples from borings DWP-B2 and DWP-B3 indicate that the angle of internal friction is between 30 and 38 degrees.

The SPT data also suggest that the sands of the lower Holocene deposits are typically dense to very dense. The correlations between SPT N-value and strength suggest that the angle of internal friction within these deposits varies from 35 degrees to in excess of 40 degrees.

Strength Properties of Fine-Grained Material

Harbor Bottom Sediments. The cohesive harbor bottom sediments have a very soft to soft consistency with (as noted by the USACE [1995]) some of the material in a state of suspension. Measured cone point resistances generally did not exceed 2 tsf and were commonly less than 1 to 1.5 tsf, which typically correlates to undrained shear strengths of less than about 200 pounds per square foot (psf). Undrained shear strengths measured using a torvane range from approximately 50 to 150 psf.

Holocene Deposits. Clay layers within the Holocene deposits generally range in consistency from very stiff to hard. SPT N-values ranging from 20 to 35 blows per foot and CPT tip resistances of between 25 and 35 tsf were measured within the clay layers in the upper Holocene deposits. The measured tip resistances correspond to undrained shear strengths of between 1,200 and 4,000 psf.

In contrast, the cone point resistances measured within the top layer of the paleochannel clay encountered in sounding CPT-36 ranged from 7 to 10 tsf. These materials are interpreted as being firm to stiff.

SPT N-values ranging from 37 to greater than 50 were measured within the clay layers in the lower Holocene materials. We interpret that these materials are hard with undrained shear strengths exceeding 4,000 psf.

Consolidation and Compressibility

State of Consolidation. Our estimate of the state of consolidation is based on the results of two consolidation tests and empirical relationships based on undrained shear strength and liquidity index. Consolidation tests were performed on samples from overwater borings DWP-B2 and DWP-B6 that were excavated below the POLA Turning Basin. As described previously, the Turning Basin was previously occupied by the Wilmington Lagoon. On the basis of survey maps presented in Weinman and Stickel (1978) and the Coast and Geodetic Survey (1908), we estimate that ground surface elevations prior to development were at approximately El. -10 to +10 feet. Predevelopment ground surface or mudline elevations that are higher than existing mudline elevations would imply that the underlying strata had been previously subject to an effective overburden pressure in excess of the current overburden stress.

The estimated existing and predevelopment pressures at the sample depths, and the estimated range of preconsolidation pressure from the laboratory consolidation tests are summarized below in measurements of kips per square foot (ksf).

Sample and Depth	Estimated Existing Overburden Pressure (ksf)	Estimated Range of Predevelopment Overburden Pressures (ksf)	Estimated Range of Preconsolidation Pressure from Laboratory Tests (ksf)
DWP-B2 at El. -84 feet	2.7	4.4 - 6.2	4.3 - 7.3
DWP-B6 at El. -40 feet	1.4	1.8- 3.6	5.3 - 6.3

Since the estimated range of preconsolidation pressures is higher than the current effective overburden pressures (p_o'), we conclude that the samples are overconsolidated with respect to the current effective overburden pressures. Additionally, the estimated range of preconsolidation pressures for the sample at El. -40 feet is significantly higher than the estimated range of predevelopment overburden pressures. However, this result is consistent with the observation that the clay materials encountered within this range of depths appeared to have been previously exposed to the atmosphere and were likely overconsolidated by desiccation.

Compressibility. The interpreted compression (C_{ec}) and recompression (C_{er}) ratios of the estuarine sediments range from 0.01 to 0.11 and 0.010 to 0.015, respectively. The consolidation test results indicate that the coefficient of consolidation (C_v) ranges from about 40 to 80 square inches per day (in.^{2}/day).

Corrosion. Corrosion tests were performed on samples that were recovered from the borings at approximately the elevation of the proposed pipeline. Two of the samples tested were obtained from onshore borings performed at the pipeline landfalls, and two samples tested were from overwater borings performed within the limits of the POLA navigation channels. The test results are presented in Appendix B, and are summarized below.

Sample	pH	Resistivity (ohms-cm)	Sulfate (mg/kg)	Chloride (mg/kg)
B-1 at 8.8 feet	10.75	480	217	229
Remaining samples	7.80 to 7.98	108 to 180	621 to 707	2413 to 4167

The test results generally indicate that the conditions are corrossive to metals and aggressive to concrete. We note that Boring B-1 was excavated on the Unocal Marine Terminal near Berth 150. Although no organic vapors nor petroleum hydrocarbons were detected, the field PID measurement testing on drill cuttings, respectively, some suggestion of possible contamination were observed in samples and cuttings obtained from that boring.

RECOMMENDATIONS FOR PIPELINE DESIGN

The following discussion presents recommendations relative to the geotechnical design and construction of the reclaimed water pipeline channel crossing. The recommendations are applicable to the portion of the pipeline that extends between the pipe-ramming pits on either side of the navigation channel. Recommendations for the design of the portions of the pipeline that are onshore of the pipe-ramming pits are beyond the scope of our study for this project, as are the evaluation of seismic hazards and the presentation of seismic design recommendations.

Channel Crossing Excavation

Preliminary plans showing the vertical alignment of the pipeline provided by DWP indicate that below the navigation channels of the Turning Basin, the pipeline invert will be at approximately El. -69 feet. Placement of the pipeline and its bedding will probably require an excavation to between about El. -70 feet to El. -72 feet. The depth of excavation below the existing harbor bottom will therefore be between about 20 to 25 feet. Greater depth of excavation, however, will be required locally at the edges of the existing Turning Basin navigation channel. Open-cut trenching techniques are proposed for the pipeline channel crossing.

On the basis of the materials encountered during our field exploration for the project, we expect that soils within the limits of the dredging for the pipeline will consist of a few feet of harbor bottom sediments and/or disturbed Holocene deposits overlying medium dense to very dense granular soils with stiff to very stiff clay layers. We expect that the inclination of trench side slopes will be controlled by the granular materials above the proposed pipeline elevation.

The majority of the granular materials encountered during our exploration are relatively poorly-graded fine sands and silty fine sands. In these types of materials, experience indicates that the inclination of relatively stable dredged side slopes depends on the method of excavation and height of the dredge cut. We expect that trenches excavated using mechanical methods will likely be stable at slope inclinations of about 3H:1V. If, however, the pipeline trench is excavated using a hydraulic dredge, the trench side slopes may have to be flatter than 3H:1V. Somewhat steeper trench side slopes may be achieved in the well-graded sands and stiff clays that were encountered locally in borings DWP-B4 and DWP-B5.

Although rock or debris were not encountered in the overwater exploration conducted for the project, past dredging experience in the Los Angeles harbor indicates that such materials may be encountered on the harbor bottom or embedded within the underlying sediments. Rock or debris could be associated with historic structures, adjacent slope protection, past construction or commerce activities, or could be redeposited material derived from sources outside the harbor area.

Bearing Capacity and Settlement

Assumed Pipeline Section. Materials and construction recommendations for pipeline backfill and bedding are considered to be outside the scope of the present study. However, for the purpose of our subsequent evaluation, we have assumed that:

- The pipeline will be supported on a minimum 1-foot of bedding consisting of gravel material;
- The bedding will extend to at least 2 feet above the pipeline; and
- That the pipeline will be protected by at least 5 feet of quarry run rock to reduce the potential for damage to the pipeline from anchors or other dragged objects.

Bearing Capacity. As described in our subsurface characterization section, soils encountered at and below El. -69 feet are generally overconsolidated, undisturbed Holocene deposits that consist of dense sands and very stiff clays. Bearing capacity is therefore estimated to be adequate for the anticipated pipeline loads in the materials underlying the pipeline invert in the bottom of the navigation channels, and beneath the sections of pipe that are rammed beneath the rock dike along the edges of the navigation channel.

We suggest that pipelines constructed over a 1-foot of compacted bedding be designed using a net allowable bearing capacity of 2,000 psf. The recommended allowable bearing pressure can be increased by one-third when considering short-term seismic loads.

Settlement. Beneath the side slopes and navigation channel, the pipeline will be underlain by Holocene deposits that are dense sands and very stiff clays. Consolidation tests indicate that these materials are overconsolidated relative to the current overburden pressures.

Settlement below the pipeline can occur due to recompression of relatively undisturbed soils that rebound during the excavation of the trench. However, we estimate that the generally overconsolidated soils encountered below the pipeline are unlikely to settle or consolidate excessively. For example, we estimate that about ½-inch of recompression settlement could occur below portions of the pipeline that are constructed over relatively undisturbed dense granular materials. The estimated recompression settlements are on the basis of an approximately 20- to 25-foot-deep open-cut trench with side slope inclinations of approximately 3H:1V. In our opinion these settlements would occur relatively uniformly along the length of the pipeline.

In our opinion, the critical settlement issues relate to possible disturbance of the underlying materials during construction and at the ramming pit where the pipe transition from onshore to sloping. The extent of construction disturbance will depend on the method of construction, and the materials encountered at the bottom elevation of the pipeline. During our field exploration for the Main Channel Deepening Program, zones of disturbed native sediments (typically 2 to 4 feet in thickness) were encountered within the limits of the channel that were dredged using hydraulic methods. On the basis of these explorations, we estimate that trenches excavated using hydraulic methods could have a similar thickness of disturbed materials below the proposed pipeline at the end of excavation. Mechanical excavation is anticipated to disturb a lesser thickness of underlying materials.

We anticipate that settlements on the order of ½-inch to 1-inch could occur if the construction disturbance of the granular materials encountered in our borings resulted in a 2-foot-thick zone of loose material below the pipeline and its bedding. Since disturbance of the underlying materials could occur in localized areas, the settlements due to recompression of disturbed materials will be similarly variable along the length of the pipeline. In our opinion, the potential for settlement due to disturbance during construction can be reduced by compaction of the underlying materials and pipe bedding.

At the pipe-ramming locations on either side of the channels, the borings indicate that fill of variable density and loose to medium dense Holocene sands extends down to about El. -15 feet on the Berth 150 side and El. -10 feet on the Berth 225 side. Thus, about 10 to 20 feet of variable and moderately dense materials will underlie the planned pipeline invert elevations of about El. -2 feet on the northern (Berth 150) side of the Turning Basin and about El. +3 feet on the southeastern (Berth 225) side of the Turning Basin.

As indicated in our evaluation of predevelopment morphology, the northern pipeline landfall is interpreted to be in the vicinity of an island and/or channels within the Wimington Lagoon. The southern pipeline landfall is interpreted to be within the limits of Rattlesnake Island. In our opinion, there is a potential for near-surface materials that were deposited in such an estuarine/marine environment to be soft or loose, and therefore compressible. The POLA (1963) drawings indicate that fill materials that were placed during construction of the dikes were likely placed directly over the pre-existing ground surface. A layer of loose to medium dense sandy material was encountered in the vicinity of the interpreted contact between artificial fill materials and Holocene deposits in borings performed at onshore locations. The pipeline invert elevation in the vicinity of the pipe-ramming pit at Berth 225 is close to the interpreted contact between artificial fill and native materials. We estimate that the differential settlement under the pipeline due to compression of loose or soft materials along the upper slope could locally be on the order of 1 inch over 10 to 20 feet.

Pipe-Ramming

At the pipeline landfalls, the DWP pipeline will pass beneath the existing dikes at Berths 225 and 150. In addition, on the southeast side of the Turning Basin, the pipe will underlie the wharf at Berth 225. To reduce the impacts that trench, or cut and cover construction techniques would have on the existing improvements in these areas, the DWP is planning to use pipe-ramming methods to advance the casing below the wharves and dikes. The pipe casing will extend from the shore to a location near the pierhead lines. We understand that a pneumatically powered pipe-ramming system is being considered for the project.

In general, the pipeline should be installed using a ramming system that is capable of advancing the pipe to the required depths without overstressing or damaging the pipe. However, consideration should also be given to reducing the potential for the pipeline to disturb the surrounding soils that support the existing wharf foundations.

Subsurface Conditions. The vertical alignment of the pipeline relative to the existing pile-supported wharf at Berth 225, and the interpreted subsurface conditions in this area are shown on Plate 7. As shown on Plate 7, the pipeline will likely encounter loose to dense fill materials and Holocene sands above approximately El.-15 feet. As discussed in our *Settlement* section, there is a potential for loose or soft deposits to be present at the base of the fill and top of the underlying Holocene sediments. However, below that elevation, the Holocene deposits are likely to be predominantly medium dense to dense granular materials with stiff clay layers. This condition exists on both sides of the Turning Basin.

In addition, gravel to cobble-sized materials that are related to the construction of the existing dikes at Berth 225 could be present in the vicinity of the proposed pipe alignment on the southeast side of the Turning Basin. Although the design cross section (reproduced on Plate 4), implies that the oversize materials extend only a limited distance below the top of the slope, the construction records for the 1960s construction of the wharf are not available and there is uncertainty relative to the inclination of the slope dredged to allow construction of the wharf.

Existing Structures. A design cross section for Berth 225 was provided by POLA (1963) and is reproduced on Plate 4. As shown on Plate 4, the wharf is supported by six rows of vertical piles and by one row of batter piles. The piles are shown to be 18-inch octagonal concrete piles. The centerline alignment of the piles and the design pile tip elevations are shown on Plate 7. We understand that the spacing (parallel to the shoreline) between pile foundations is approximately 12 feet on centers.

For the purpose of our evaluation, we assume that the pile foundations were installed in a regular rectangular grid. To reduce the potential for disturbance to existing foundations, the casing should be advanced midway between rows of piles. For the proposed casing, we estimate that the clear distance between the casing and the pile foundations will be approximately 3¼ feet, assuming that the horizontal alignment of the pipeline is maintained. As shown on Plate 7, the tip elevation of the outermost rows of piles was designed to be El. -70 feet. This implies that the bottom of the reclaimed water pipeline will pass within about 14 feet above the design tip elevation of the outermost row of piles.

Design Recommendations. Difficult ramming conditions could be encountered within the relatively dense Holocene deposits or within the cobbles of the existing dike fill materials under the wharf. To reduce the potential for difficult driving conditions to impact the project, we recommend that consideration be given to advancing the pipe with an open casing. Spoils that accumulate within the pipe as it is advanced can be cleaned out using augers. The pipe-ramming system should be capable of delivering sufficient energy to advance the pipe through these materials.

The project design should review the thickness of the proposed pipe relative to the stresses that they could be subject to during construction. To optimize the thickness of the pipe, and to reduce the potential for damage to the open end of the casing and deflection from the design alignment, a point attachment can be used at end of the pipe.

Within the relatively dense granular materials, jetting or lubrication is a method that is sometimes considered to reduce the internal and/or external frictional resistance between the pipe and the surrounding soils or spoils. We understand that the DWP has decided not to consider jetting as a method of advancing the casing.

Although it is important to provide techniques to allow advancement of the pipe-ramming through difficult subsurface conditions, it is similarly necessary to prevent disturbance to the soil as the pipe is rammed. For example, augers should not be used to predrill a hole in front of the pipe for portions of the pipeline that are adjacent to existing piles. To reduce the potential for disturbance to the surrounding soils, and to minimize deviation from the preferred alignment, we recommend that:

- Whenever possible, the pipe-ramming equipment should be operated at a relatively low power setting;
- Spoils should be removed using an auger for portions of the pipeline that will be adjacent to the existing piles;
- Point attachments at the end of the pipe have a diameter that is not significantly greater than the diameter of the pipe; and

Impacts of Soil Disturbance. As discussed above, the proposed pipe-ramming could result in disturbance of the soil surrounding the pipeline. Disturbance of the soil above the tip of the existing pile foundations could reduce the lateral capacity of the pile and soften the lateral load-deflection characteristics of the pile. Disturbance around the sides of the pile also could reduce the skin friction along the sides of the pile. Such a reduction in the frictional resistance of the pile could result in an increase in the mobilized end bearing support for the pile. Since the mobilization of end bearing resistance generally requires greater pile displacement than the mobilization of frictional resistance, additional settlement of the pile and a softer response to live loads will likely be observed due to reduction in skin friction resistance. In addition, disturbance of soil in the vicinity of the tip of the pile foundations could result in reduction in end bearing resistance at the tip of the pile.

We recommend that the project design consider the potential impacts to the existing foundations in the event that pipe-ramming activities significantly disturb the foundation support soils. We note that the impacts of soil disturbance may not be observed under the relatively low dead loads of the wharf structure, but could manifest themselves during subsequent loading of the wharf.

Possible Monitoring Activities. We recommend that consideration be given to monitoring the wharf to allow comparison of its condition before and after construction of the pipeline. Monitoring will likely either provide insight relative to evaluation of possible disturbance caused by the pipe-ramming or provide an increased comfort that the pipe-ramming did not affect the wharf. Possible monitoring activities to evaluate changes in foundation support conditions include load testing of the wharf, wharf deflection surveys, underwater inspections, and multi-beam hydrographic surveys. These options are summarized below.

Prior to the performance of pipe-ramming operations, the wharf deck elevations should be surveyed under the existing dead loads. A heavy load should then be placed on the wharf (e.g., a row of cement trucks) and the deck elevations resurveyed to estimate the deflections due to the applied loads. The load test can then be repeated after construction. Increased deflections of the wharf deck in the vicinity of the pipeline following construction would indicate that foundation support for the structure had been reduced.

In addition, a dynaflex pavement deflection survey (such as is performed prior to the design of overlays for pavements) could be performed on the wharf prior to and after construction of the pipeline. Increased deflection in the vicinity of the pipeline alignment, after installation, could imply reduced foundation support for the structure.

Existing mudline elevations at the piles can be marked on the piles by divers or measured using a sounding line from a marked position above the water surface prior to construction. The mudline elevation can then be observed or remeasured following construction. Observations of lower mudline elevations around the pile would imply that foundation soil had been disturbed. However, the absence of any changes in mudline elevation would not preclude the disturbance of soil, since arching of soil over voids or disturbed zones could reduce the potential for disturbance to be visible at the mudline.

A multi-beam hydrographic survey is recommended to illuminate and map the slope underneath the wharf in the area between the two pile rows. Comparison of conditions before and after pipe-ramming would provide similar information to that based on the soundings adjacent to the piles. The multi-beam hydrographic survey, however, would be more likely to define small elevation differences directly over the pipeline, which will be located between the pile rows.

Temporary Shoring

We understand that pipe-ramming will likely be initiated from ramming pits that will be excavated with vertical side slopes. At the Unocal Marine Terminal landfall near Berth 150, a minimal excavation will be made to start the pipe-ramming operation, while at the Yusen Terminal near Berth 225, the base of the pipeline will be at approximately El. +3 feet. On the basis of the surface elevations shown on maps and sections provided by DWP, we estimate that excavations that are 12 to 15 deep will be required at the landfalls.

Temporary excavations that are over 5 feet deep should be designed according to the applicable safety regulations and standards of State of California, Occupational Safety and Health Administration (CAL/OSHA). Temporary shoring systems should be designed by the contractor. As guidance for design, we have estimated preliminary lateral earth pressures (equivalent fluid weights) for the design of temporary shoring systems for ramming pits that are excavated with vertical side slopes.

Our preliminary design recommendations for temporary structures is on the basis of the materials encountered in our onshore borings DWP-B1 and DWP-B7. As described in this report, the materials encountered within the depths described above have been interpreted to be artificial fill. Due to the complex history of land reclamation and subsequent land use in these areas, in our opinion, there is potential for lateral and vertical variation of subsurface conditions. The recommended design parameters should be re-evaluated on the basis of the soil conditions revealed during construction.

Temporary shoring systems may be cantilevered, braced, or tied-back systems. For use with CAL/OSHA guidelines, we interpret that the soil conditions encountered within the estimated depth of excavation in borings at the two pipeline landfalls are Type C granular soils. Cantilever shoring systems may be designed for active earth pressures. Tied-back shoring systems may be designed for triangular earth pressure distributions based on at-rest earth pressures while braced shoring systems can be designed based on rectangular earth pressure distributions. The shoring system design (including bracing and tiebacks) should also consider surcharge loads above the top of the excavation. Schematic diagrams illustrating the earth pressure distributions for different types of shoring and loading are presented on Plate 9 - Earth

Pressures for Temporary Shoring. Our recommended lateral earth pressures estimated for level backfill conditions are as follows:

Depth Interval	Equivalent Fluid Weights (pcf)			
	Active Earth Pressure	At-Rest Earth Pressure	Hydrostatic Pressure	Passive Earth Pressure
Above water level in dry soil	40	65	0	300
Below water level	20	35	63	210

The tabulated values are based on a soil unit weight of 130 pcf. The values presented above do not provide for surcharge conditions resulting from structures or construction equipment. Additional lateral loads because of surcharge loading should be computed based on a lateral earth pressure coefficient of 0.3 for active conditions and 0.5 for at-rest conditions.

In our opinion, construction will be impacted by the presence of groundwater at these elevations. We recommend that dewatering systems be designed to maintain a dry trench.

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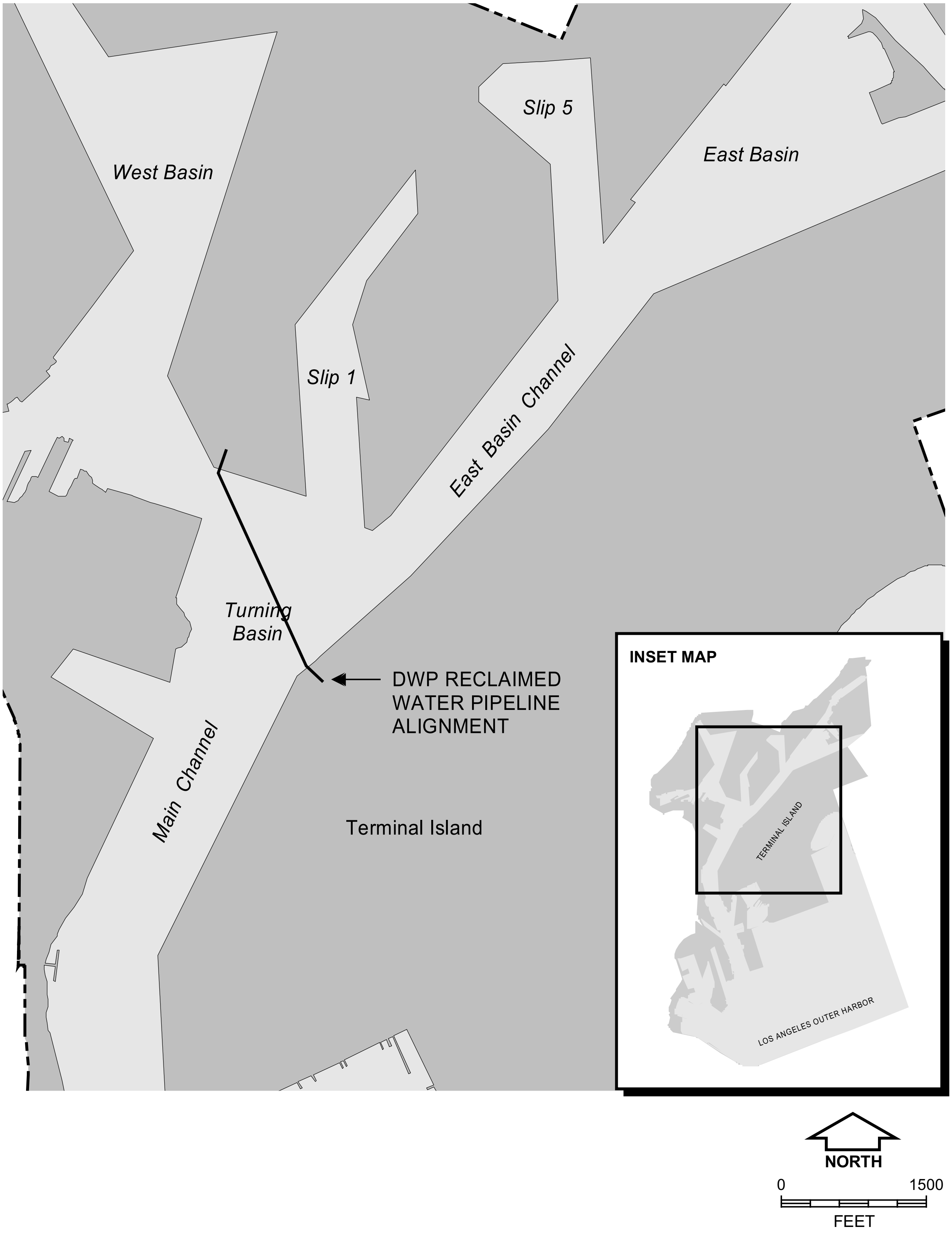
PLATES

June 1997
Project No. 96-42-1217



VICINITY MAP
DWP Reclaimed Water Pipeline
Port of Los Angeles

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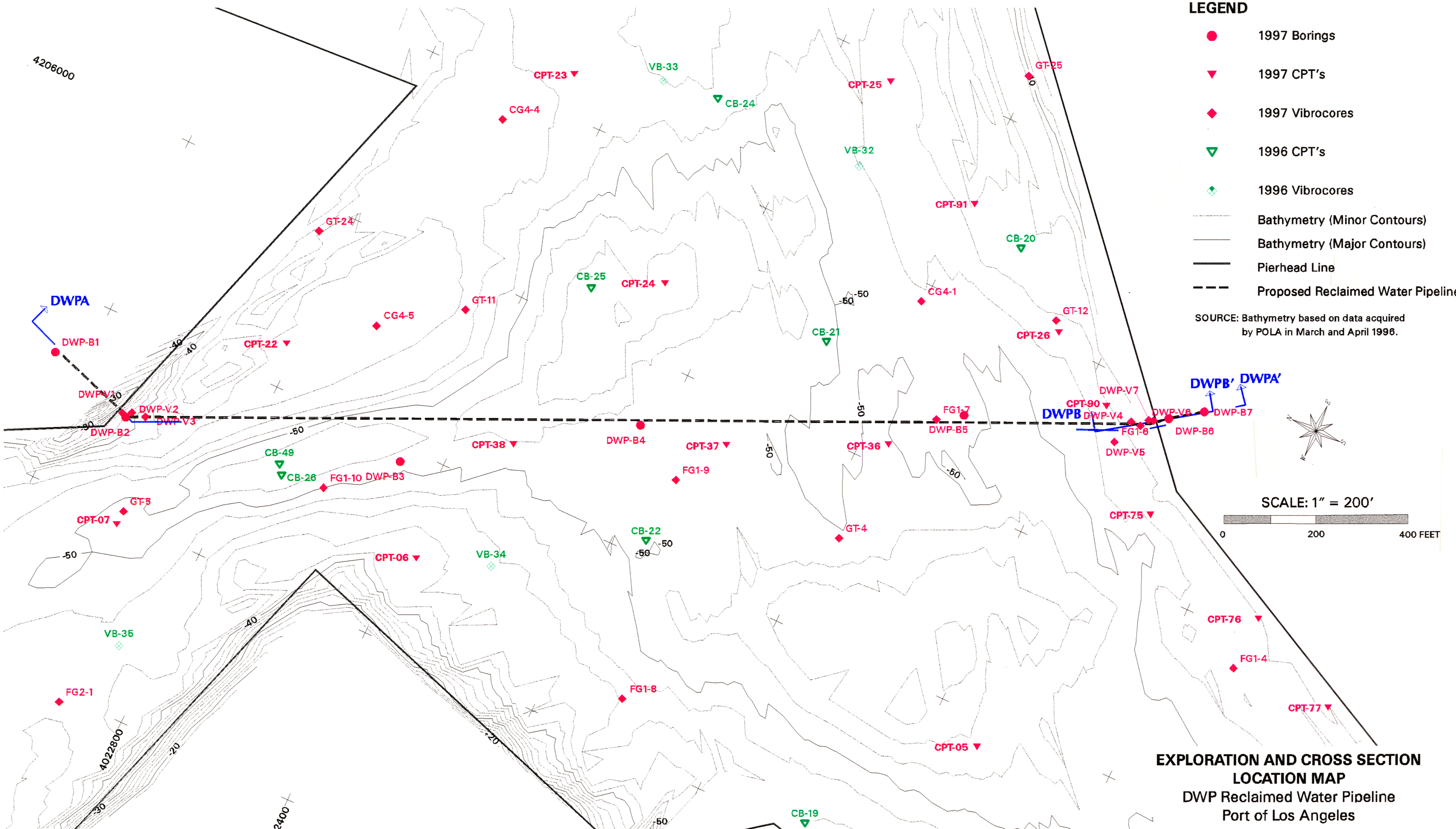
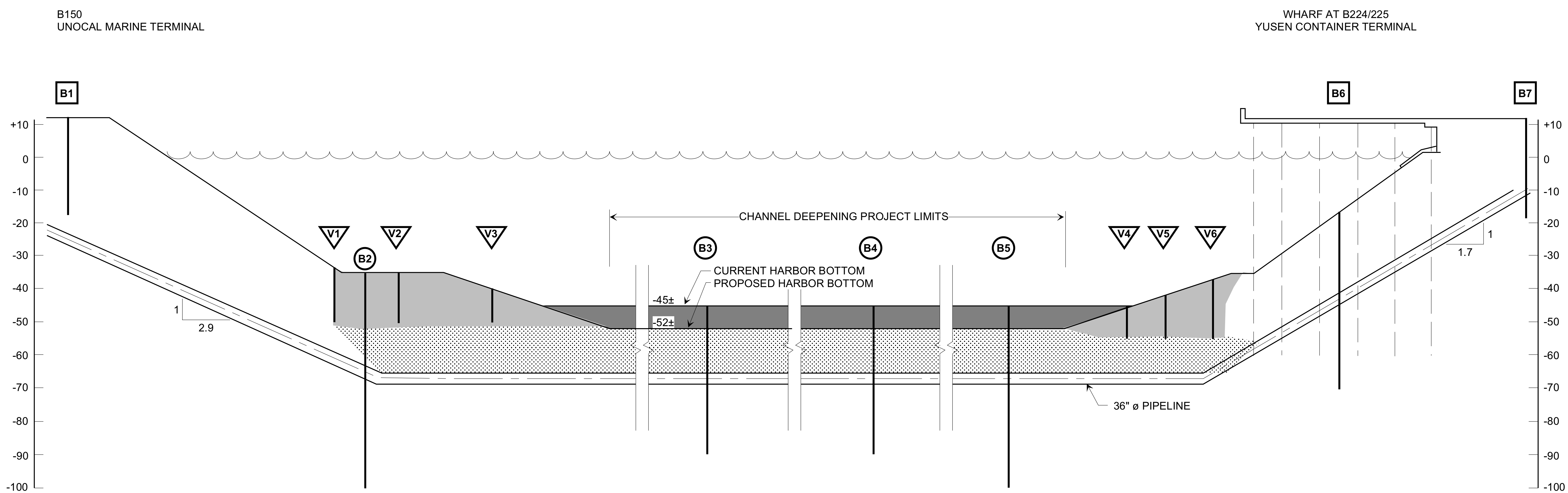
PLATE 1

FUGRO



EXPLORATION AND CROSS SECTION LOCATION MAP
DWP Reclaimed Water Pipeline
Port of Los Angeles

PLATE 2



LEGEND

B1	Onshore Boring
B2	Overwater Boring
V1	Nearshore Vibrocore

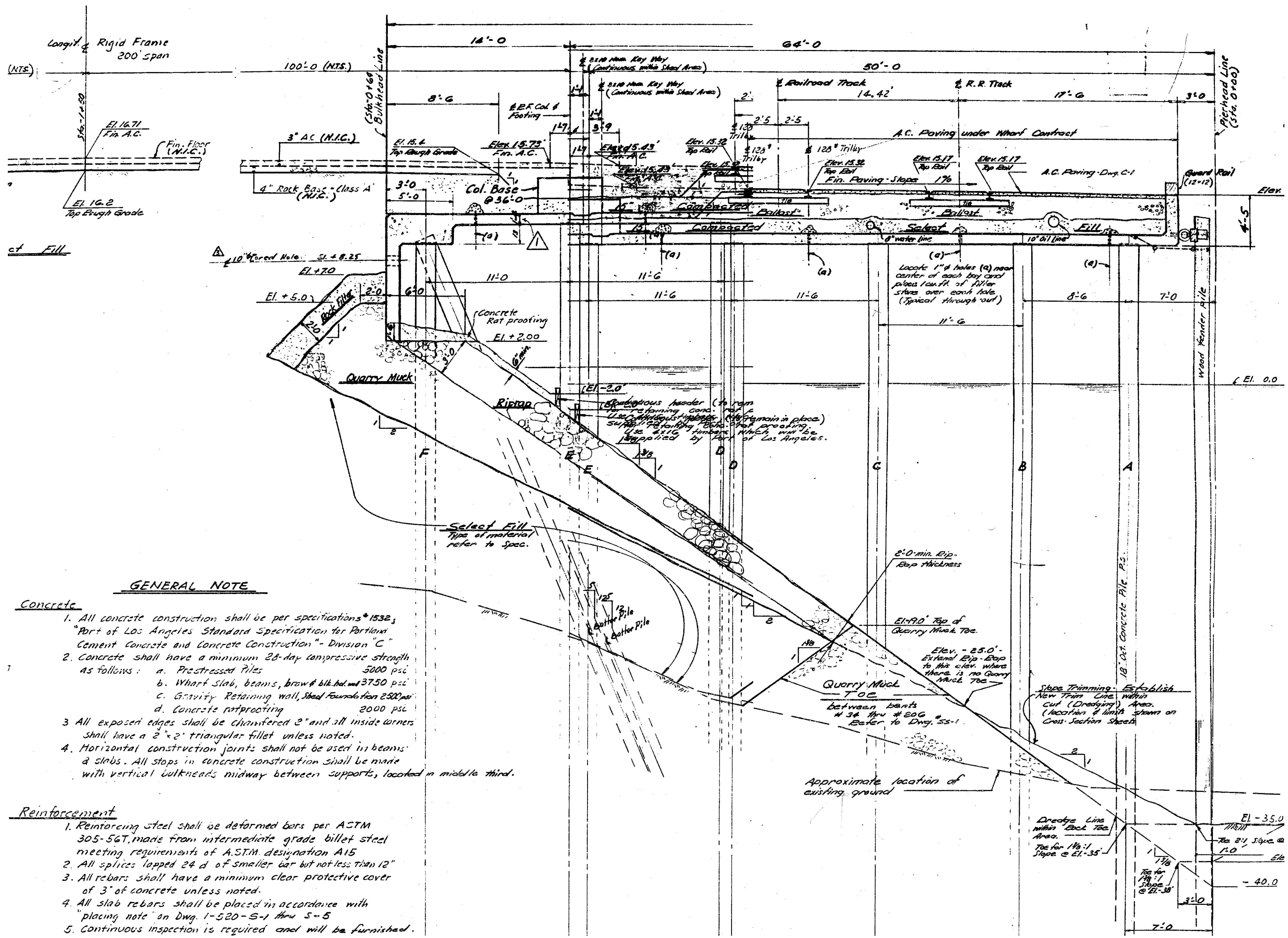
ENVIRONMENTAL CHARACTERIZATION FROM:

- POLA Vibrocore
- Nearshore Vibrocore
- Overwater Borings

PIPELINE PROFILE AND FIELD EXPLORATION SCHEME
DWP Reclaimed Water Pipeline
Port of Los Angeles

PLATE 3

9642\1217XSCT.DS4



GENERAL NOTE

Concrete

1. All concrete construction shall be per specifications #1532, "Port of Los Angeles Standard Specification for Portland Cement Concrete and Concrete Construction" - Division "C"
2. Concrete shall have a minimum 28-day compressive strength as follows:
   a. Prestressed Piles 5000 psi
   b. Wharf Slab, beams, brow & blk. hd. wall 3750 psi
   c. Gravity Retaining wall, Shed Foundation 2500 psi
   d. Concrete ratproofing 2000 psi
3. All exposed edges shall be chamfered 2" and all inside corners shall have a 2" x 2" triangular fillet unless noted.
4. Horizontal construction joints shall not be used in beams & slabs. All stops in concrete construction shall be made with vertical bulkheads midway between supports, located in middle third.

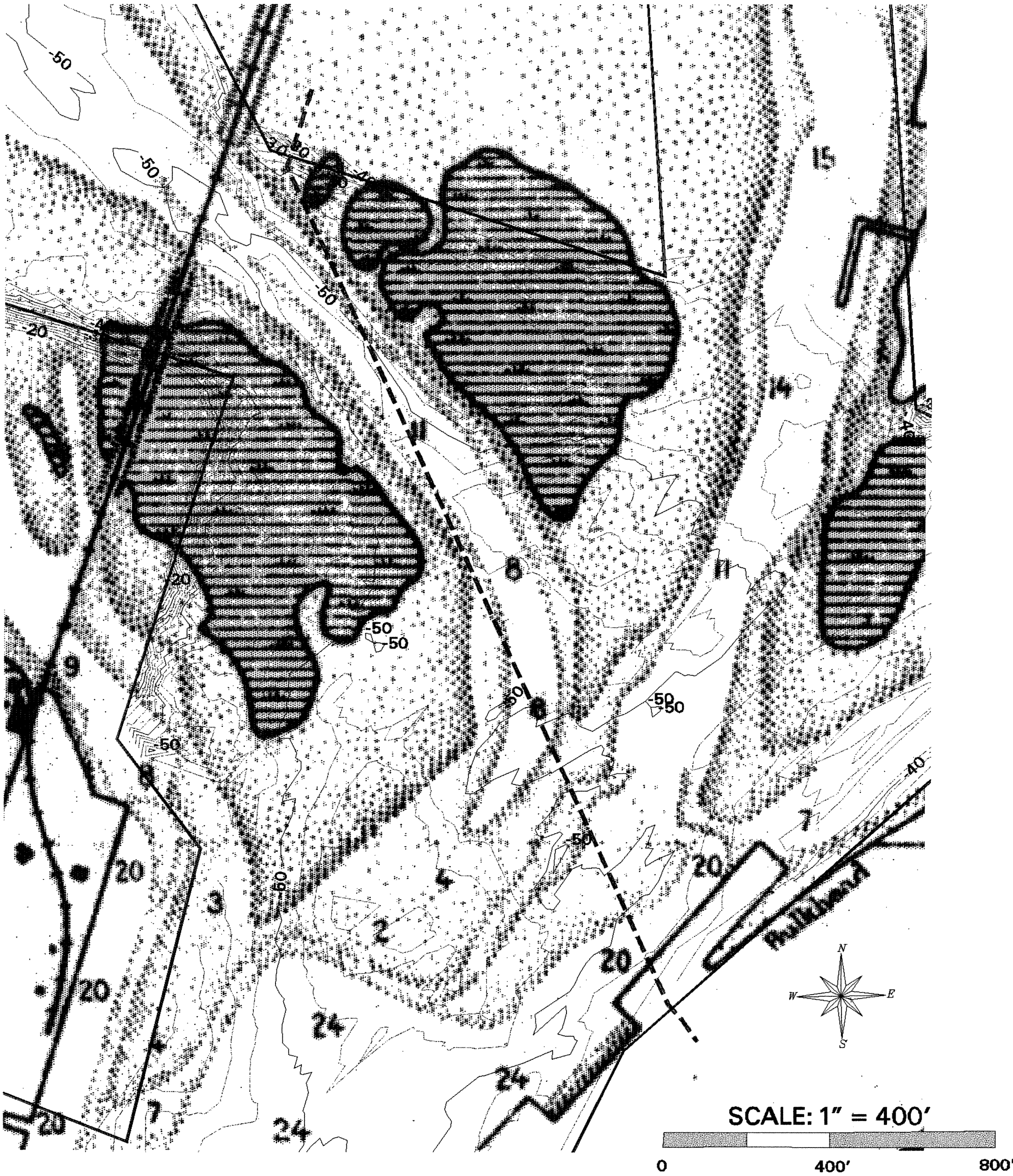
Reinforcement

1. Reinforcing steel shall be deformed bars per ASTM 305-56T, made from intermediate grade billet steel meeting requirements of A.S.T.M. designation A15
2. All splices lapped 24 d of smaller bar but not less than 12"
3. All rebars shall have a minimum clear protective cover of 3" of concrete unless noted.
4. All slab rebars shall be placed in accordance with "placing note" on Dwg. 1-520-S-1 thru S-5
5. Continuous inspection is required and will be furnished.

Source: POLA Drawing No. 1-520 (1963)

DESIGN WHARF
CROSS SECTION - BERTH 225
DWP Reclaimed Water Pipeline
Port of Los Angeles

PLATE 4



Bathymetry (Minor Contours)

Bathymetry (Major Contours)

Pierhead Line

Proposed Reclaimed Water Pipeline

NOTE: The morphology shown on this map depicts conditions as they existed in about 1907/08. The data were computer scanned from a large "San Pedro Harbor" map created by the Coast and Geodetic Survey in 1907/08. The outline of the Port of Los Angeles and the morphology have been adjusted to an approximate common datum.

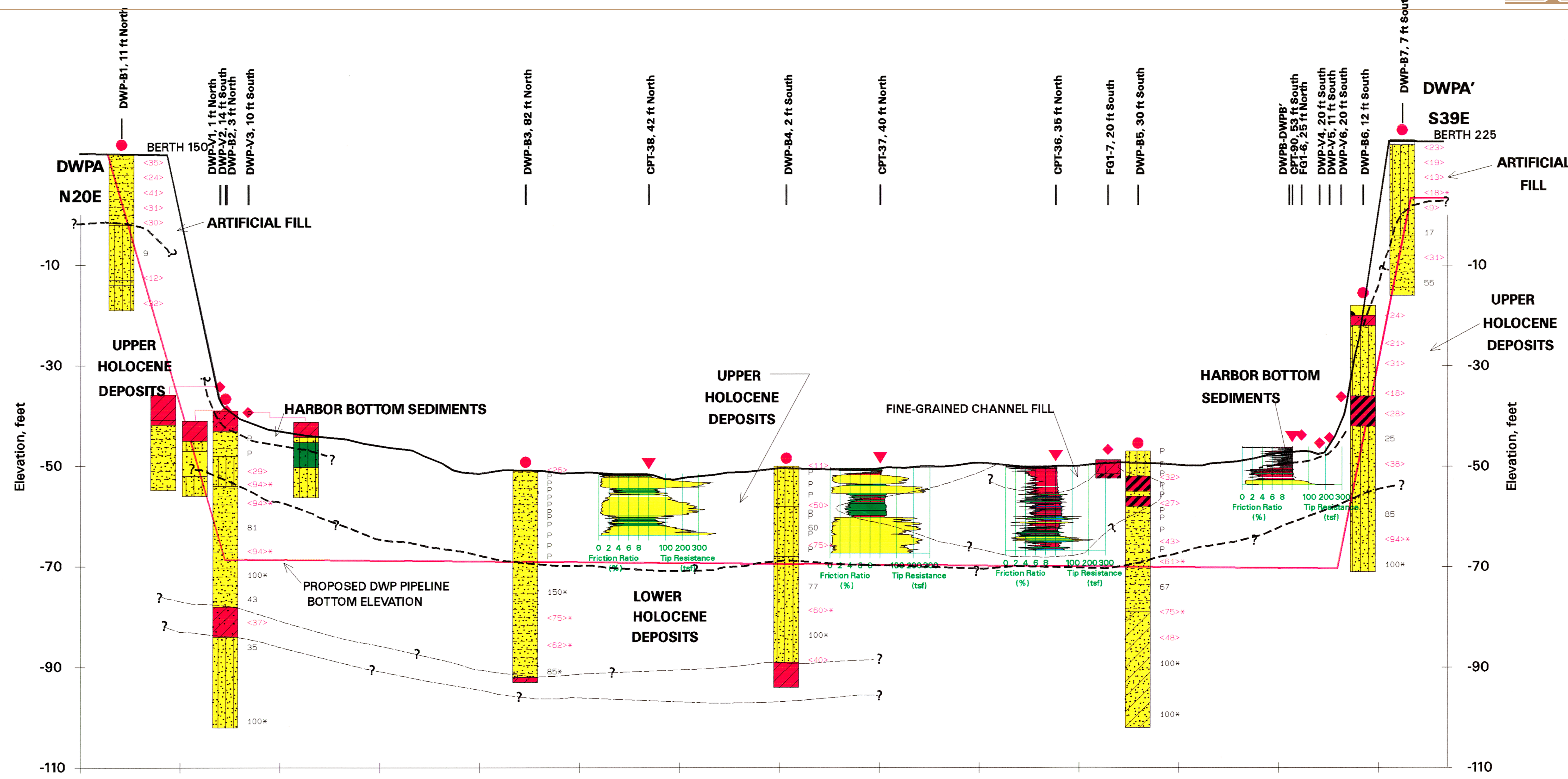
PREDEVELOPMENT MORPHOLOGY

DWP Reclaimed Water Pipeline

Port of Los Angeles

PLATE 5

June 1997
Project No. 96-42-1217



20′
0 200′

Vertical Exaggeration = 10X
CPT Tip Resistance: 1″ = 600 tsf
CPT Friction Ratio: 1″ = 20 percent
Exploration logs are projected a maximum of 100 feet into the section.

NOTES:

1) Refer to Plate 2 for cross section locations.

2) Data concerning subsurface conditions were obtained at boring, vibrocore, and CPT locations only. Actual conditions between exploration points may differ from the generalized profile shown here.

3) CPT, vibrocore, and boring logs were projected onto the section line.

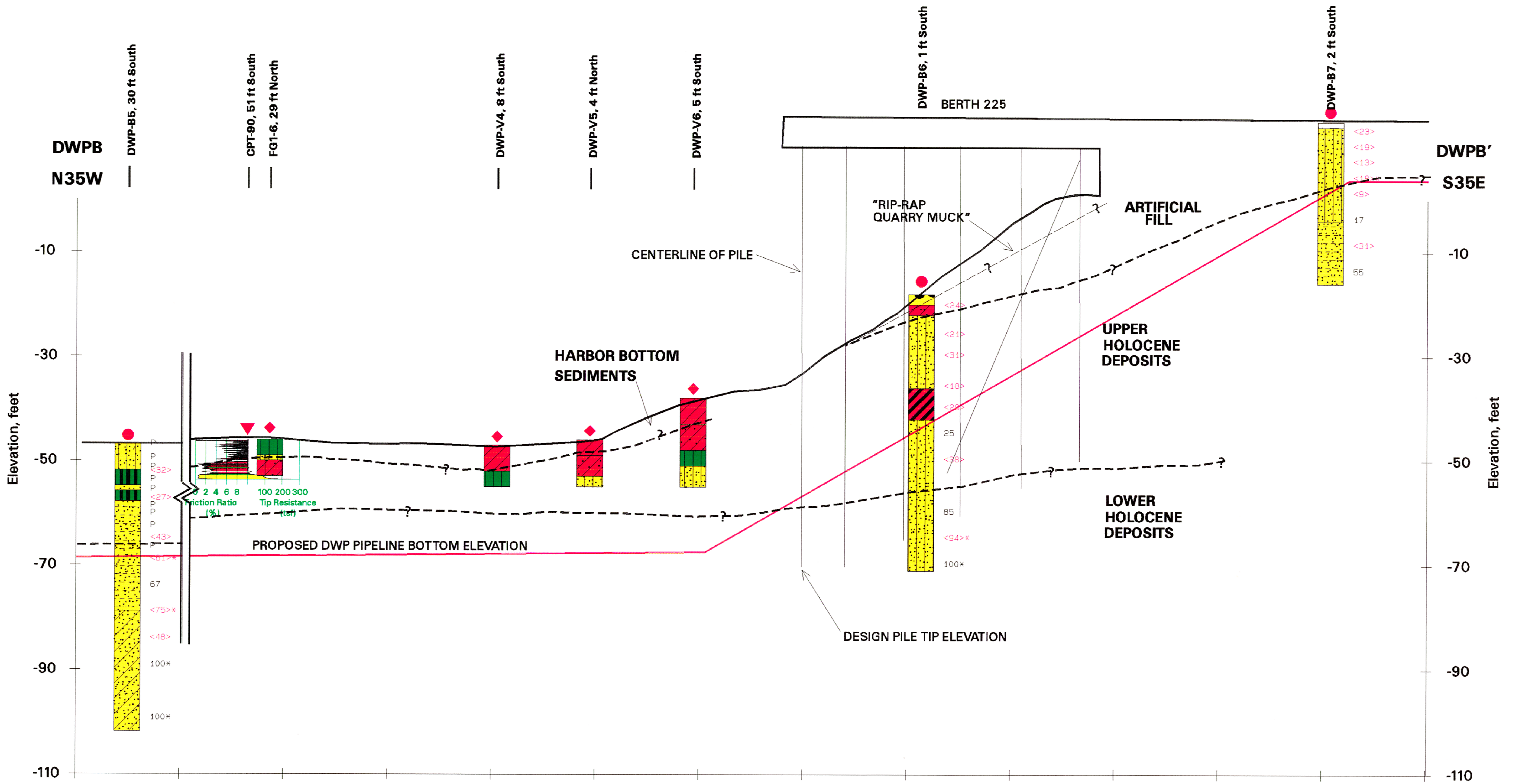
4) The CPT interpretations presented are based on empirical correlations. Those correlations may represent a simplification of actual conditions encountered at the time of exploration at the explored location.

5) Refer to Plate 8 for key to cross sections.

6) For clarity, vibrocore logs DWP-V4 through DWP-V6 and FG1-6 are not shown on this cross section. Refer to Plate 7 to see the interpreted stratigraphy near Berth 225.

SUBSURFACE CROSS SECTION DWPA-DWPA′
DWP Reclaimed Water Pipeline
Port of Los Angeles

PLATE 6



20'
0
20'

Vertical Exaggeration = 1X
CPT Tip Resistance: 1" = 600 tsf
CPT Friction Ratio: 1" = 20 percent
Exploration logs are projected a maximum of 100 feet into the section.

NOTES:

1) Refer to Plate 2 for cross section locations.

2) Data concerning subsurface conditions were obtained at boring, vibrocore, and CPT locations only. Data presented on a design cross-section provided by POLA (see Plate 4) were used to interpret subsurface conditions near Berth 225. Actual conditions between exploration points may differ from the generalized profile shown here.

3) CPT, vibrocore, and boring logs were projected onto the section line.

4) The CPT interpretations presented are based on empirical correlations. Those correlations may represent a simplification of actual conditions encountered at the time of exploration at the explored location.

5) Refer to Plate 8 for key to cross sections.

SUBSURFACE CROSS SECTION DWPB-DWPB'
DWP Reclaimed Water Pipeline
Port of Los Angeles

PLATE 7

Key to Soil Lithology Symbols

Well graded GRAVEL (GW)

Poorly graded GRAVEL (GP)

GRAVEL with sand (GP or GW)

Clayey GRAVEL (GC)

Silty GRAVEL (GM)

Well graded SAND (SW)

Poorly graded SAND (SP)

SAND with gravel (SP or SW)

Clayey SAND (SC)

Silty SAND (SM)

SAND with silt (SP-SM)

Fat CLAY (CH)

Lean CLAY (CL)

Sandy CLAY (CL)

Silty CLAY (CL-ML)

Elastic SILT (MH)

SILT (ML)

Sandy SILT (ML)

Clayey SILT (ML/CL)

Highly Plastic ORGANICS (OH)

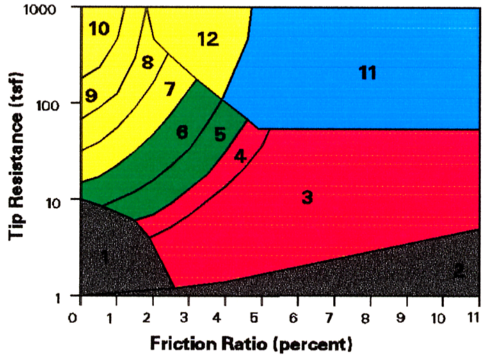
Low plasticity ORGANICS (OL)

Key to Blow Count Data

45	- Standard Penetration Test (SPT) Blow Count
<25>	- Equivalent SPT Blow Count Estimated from Modified California Sampler Blow Count
39*	- Extrapolated Blow Counts for Sampler Penetrations of less than 18"
P	- Shelby Tube Push Sample

KEY TO CROSS SECTIONS
Soil Borings and Vibrocores
DWP Reclaimed Water Pipeline
Port of Los Angeles

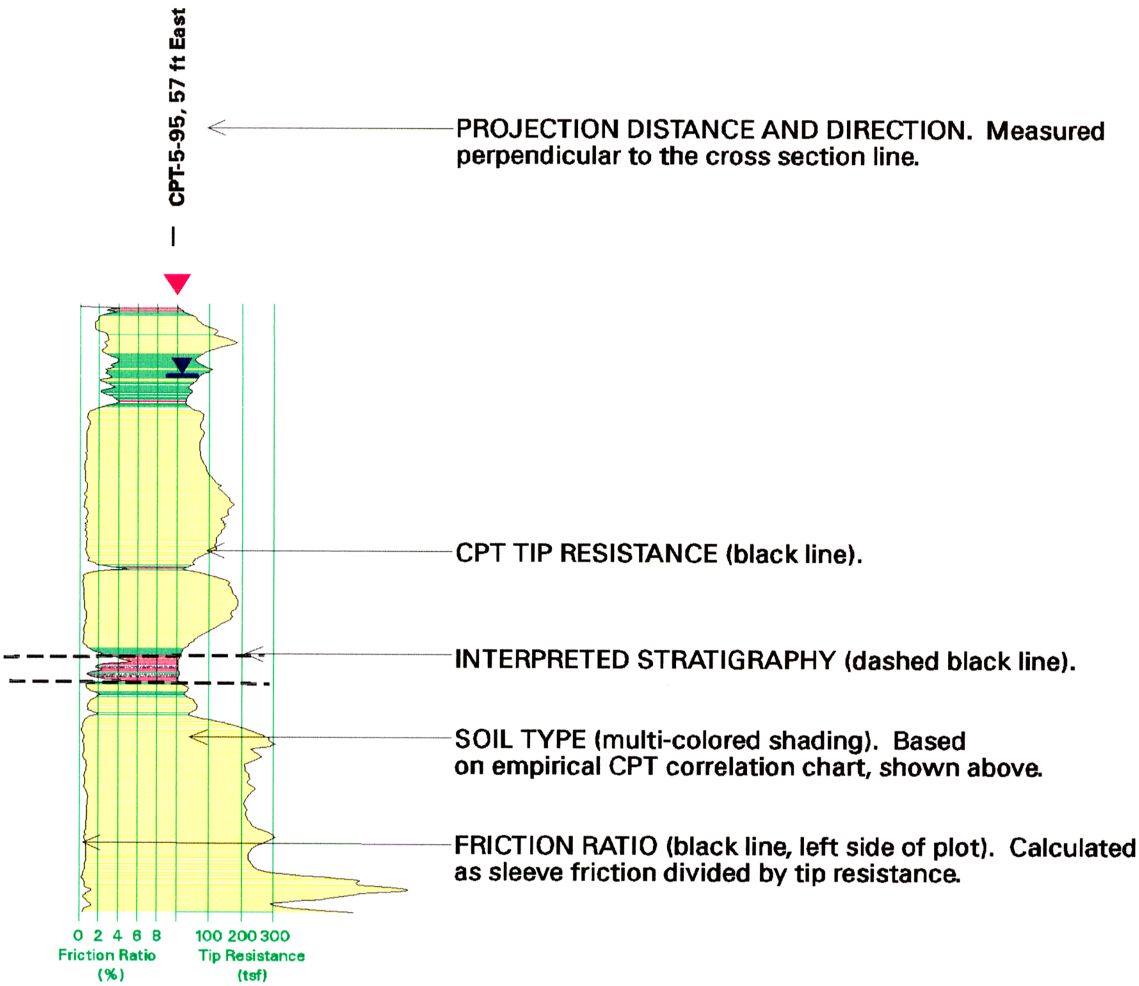
PLATE 8a



Zone	Soil Behavior Type	U.S.C.S.
1	Sensitive Fine-grained	OL-CH
2	Organic Material	OL-OH
3	Clay	CH
4	Silty Clay to Clay	CL-CH
5	Clayey Silt to Silty Clay	MH-CL
6	Sandy Silt to Clayey Silt	ML-MH
7	Silty Sand to Sandy Silt	SM-ML
8	Sand to Silty Sand	SM-SP
9	Sand	SW-SP
10	Gravelly Sand to Sand	SW-GW
11	Very Stiff Fine-grained *	CH-CL
12	Sand to Clayey Sand *	SC-SM

* overconsolidated or cemented

CPT CORRELATION CHART (Robertson and Campanella, 1984)



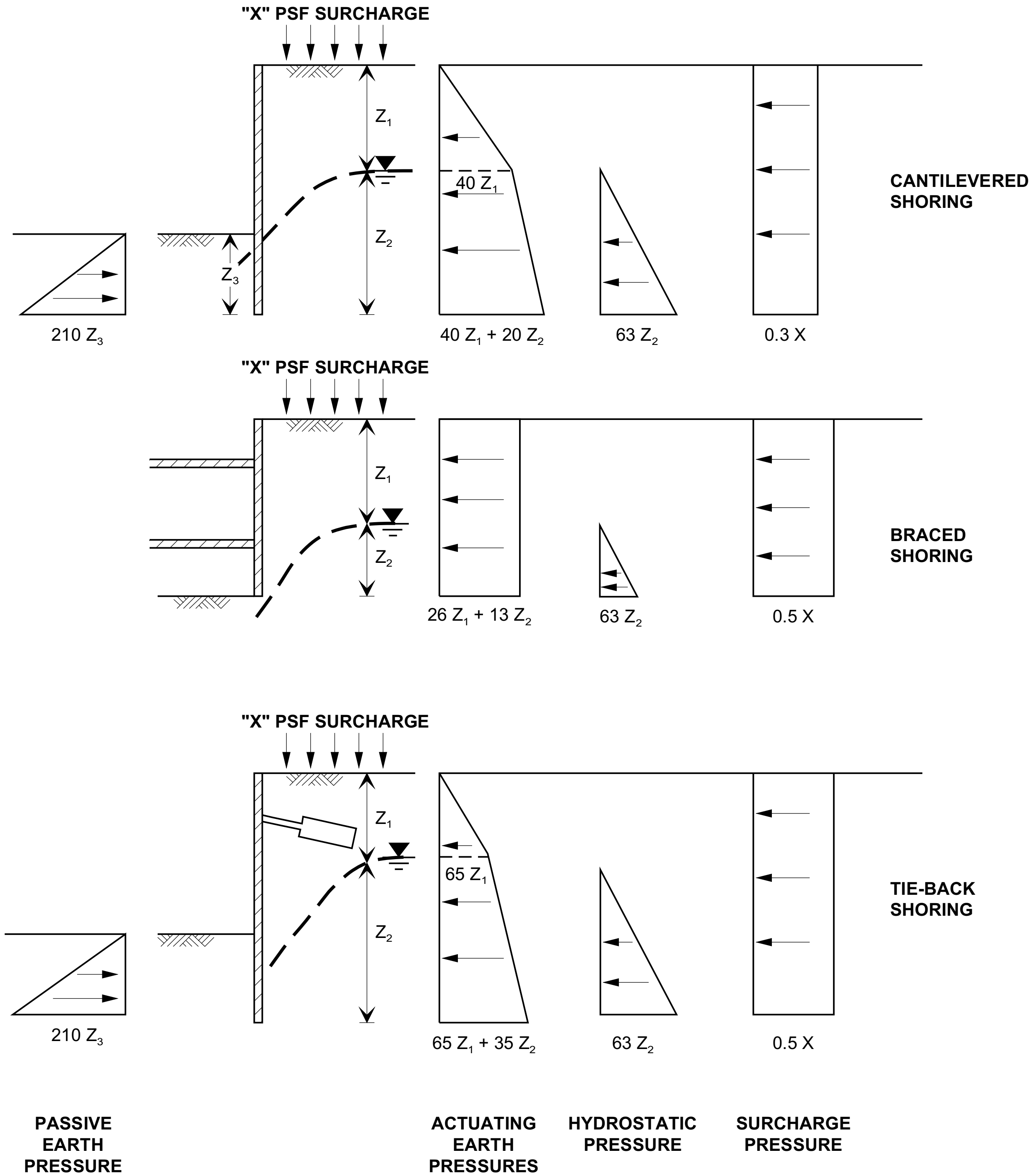
KEY TO CROSS SECTIONS

CPT Logs

DWP Reclaimed Water Pipeline

Port of Los Angeles

PLATE 8b



EARTH PRESSURES FOR TEMPORARY SHORING

DWP Reclaimed Water Pipeline
Port of Los Angeles

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APPENDIX A
FIELD EXPLORATION DATA

APPENDIX A
FIELD EXPLORATION DATA

Scope of Exploration

The subsurface exploration conducted specifically for the City of Los Angeles Department of Water and Power (DWP) reclaimed water pipeline included the advancement of seven borings (designated as DWP-B1 through DWP-B7) and seven vibrocores (designated as DWP-V1 through DWP-V7). Our field investigation program was intended to characterize subsurface conditions in the project vicinity and to provide samples for both geotechnical and environmental laboratory testing.

The seven borings included four overwater borings (DWP-B2 through DWP-B5) drilled in the Turning Basin, two land borings (DWP-B1 and DWP-B7) drilled near the planned pipeline landfall locations, and one boring (DWP-B6) drilled through the wharf at Berth 225. The seven vibrocores included three vibrocores (DWP-V1 through DWP-V3) between the edge of the navigation channel and the toe of the Berth 150 dike, and four vibrocores (DWP-V4 through DWP-V7) between the edge of the navigation channel and the toe of the dike at Berth 225.

The locations of the borings and vibrocores are shown on Plate 2. A summary of the dates of exploration, location, and surface elevation for each boring and vibrocore location is provided on Plate A-1. The surveyed coordinates conform with California Coordinate System Zone VII. Elevations are referenced to mean lower low water (MLLW) datum.

Borings

The seven borings for the DWP reclaimed water pipeline were drilled between April 22 and May 2, 1997. The execution of the DWP boring program was conducted together with the execution of the boring program for the proposed City of Los Angeles Department of Public Works (DPW) Fries Avenue force main relocation across the Inner Harbor East Channel. The sequence of drilling included the completion of all overwater borings for both projects followed by the advancement of the land borings for both projects. The specific sequence of the borings was based on the requirements imposed by navigation access in the channels and terminal operations in the onshore areas.

Overwater borings were excavated to a depth of approximately 41 to 66 feet below the existing harbor bottom. The borings drilled through the Berth 225 wharf deck were advanced to a penetration of about 53 feet. The onshore borings were excavated to depths of approximately 31 feet below the existing ground surface.

Drilling Equipment and Methods. The borings were excavated using a truck-mounted Failing 1500 rotary drill rig operated by Pitcher Drilling Company of Palo Alto, California. The borings had a nominal diameter of 5 inches. Drilling operations were performed using rotary-wash drilling methods. Non-toxic drilling mud (Revert) was used for overwater locations, and bentonite mud was used on land to suspend and remove drill cuttings and to provide lateral pressure to support the sidewalls of the borings.

The offshore drilling activities were conducted from an approximately 55-foot by 24-foot barge supplied and operated by Hamilton Marine of Long Beach, California. Pitcher's truck-mounted drill rig was secured to the barge so that the boring could be advanced through a center well in the barge, which was then towed and positioned over the proposed drilling location by a 40-foot, 65-ton twin screw tug boat supplied and operated by Hamilton Marine. The barge was held on position using a four-point anchor spread.

Prior to initiation of drilling, the depth of the water at the overwater boring locations was measured using a lead sounding line (i.e., weighted tape measure). The measured water depths were corrected to MLLW tidal datum using predicted tide tables reported to the nearest quarter-hour for the Port of Los Angeles (POLA) Inner Harbor.

The boring drilled through the wharf deck at Berth 225 was advanced by first coring through the wharf and then setting a casing down to the slope underlying the wharf. The concrete wharf deck at Berth 225 was cored using Pitcher's truck-mounted drill rig prior to the performance of boring DWP-B6. A 6-inch hole was augured through the pavement section above the concrete deck. The sides of the hole were stabilized with bentonite and water, and a carbide-tipped core barrel was used to advance a 6-inch hole through the deck. Casing (with a 6½-inch coupling to prevent the casing from dropping through the wharf deck) was set on top of the concrete wharf deck and grouted. Drilling operations for boring DWP-B6 were performed through the casing.

Geotechnical Sampling and Logging Procedures and Equipment. The drilling was performed under the technical guidance and observation of a Certified Engineering Geologist from Fugro, who prepared logs of the soil conditions encountered and obtained soil samples for laboratory observation and testing. The soils were classified in the field according to the Unified Soil Classification System. A variety of push and driven geotechnical samples were collected during the drilling program. The various sampling methods are described in the table below.

Type of Sampling	Sampler Description	Description of Sampling Method
SPT Samples	2-inch-OD, 1-3/8-inch-ID	The Standard Penetration Test (SPT) Sampler was attached to B-rod drill pipe, which was lowered through the drilling mud to the sample depth. The sampler was driven with a 140-pound hammer attached to the top of the B-rod string. The hammer was raised approximately 30 inches using a typical two-wrap cathead hoist system on the drill rig and dropped for successive blows. The SPT test was performed in general conformance with standard test method ASTM D1586.
California Modified Samples	3-inch-OD, 2-3/8-inch-ID	The California Modified Test Sampler was attached to B-rod drill pipe, which was lowered through the drilling mud to the sample depth. The sampler was driven with a 140-pound hammer attached to the top of the B-rod string. The hammer was raised approximately 30 inches using a typical two-wrap cathead hoist system on the drill rig and dropped for successive blows.
Push Samples	3-inch-OD, 2-7/8-inch-ID (thin-walled tube)	The thin-walled tube was either attached to B-rod drill pipe using a Shelby head adapter, or attached to an Osterberg piston sampler. The thin-walled tube was pushed into the sample increment using the drill rig's hydraulic system. The tube was then removed from the hole and extruded onsite with geotechnical samples retained in quarts. The test was performed in general conformance with standard test method ASTM D1587.

Geotechnical samples from the borings were generally taken at approximately 3-foot intervals to the planned bottom of pipe elevation and at about 5-foot intervals thereafter. Both driven and pushed soil samples were obtained from the borings.

The first one or two samples in overwater borings were generally obtained using an Osterberg piston sampler. Following this, casing was driven to refusal and the slough inside the casing drilled out prior to recovery of the subsequent sample. The casing was then advanced incrementally after each sample was obtained. Casing was typically set at about 20 feet below the mudline when circulation of the drilling mud was achieved.

At each overwater sample depth, the sample penetration below the water line, the time, and the estimated tide elevation were recorded. The sample penetration (depth from the mudline to the top of the sample) was calculated by estimating the change in tide between initiation of drilling (reference tide) and the time of sampling (sample tide). Sample elevations in boring DWP-B6 were estimated relative to the elevation at the top of the wharf deck (El. +15 feet).

Health and Safety Monitoring. Field photoionization detector (PID) readings (for volatile organic hydrocarbons) were obtained for selected samples. The monitoring was performed on samples down to at least 15-foot depth for the onshore borings, and for samples above EL. -70 feet for the overwater borings. The field monitoring included the placement of the soil from one sample ring (typically the uppermost ring of each sampling interval) into a sealable plastic bag, placement of the bag in the sun for several minutes, and monitoring the headspace in the bag with a precalibrated hNU PID.

Sample Splits for Environmental Testing. Sample splits were taken from the samples collected above the proposed dredge depth in borings DWP-B3 through DWP-B5. Sample splits for environmental testing were obtained from the samples collected between approximately El. -52 feet to El. -72 feet (El. -70 feet plus a 2-foot overdredge allowance), which corresponds to the approximate range of elevations between the bottom depth sampled during the Channel Deepening Program and the bottom of the proposed pipeline. To provide adequate material for sample splits for environmental sediment chemistry and bioassay tests, most of the samples in that interval were collected using driven California liner or pushed-tube samplers.

Prior to collection of all samples for possible environmental testing, the sampling equipment was decontaminated prior to each use by a detergent (TSP) wash and deionized water rinses (two to three) to prevent cross-contamination. After retrieval of the sampler, the sample was divided to provide specimens for both geotechnical testing and environmental purposes.

The environmental subsamples in each overwater boring were mixed to obtain a homogeneous sample from the environmental sampling interval. At the completion of drilling, the environmental composites from each boring were combined to provide one horizontal composite of the interval below the shallowest elevation sampled by the POLA Main Channel Deepening Program vibrocores. A discrete sample from each boring was also retained for possible environmental testing. The samples, which were refrigerated following extrusion from the sampling tubes, were provided to Kinnetic Laboratories personnel under chain-of-custody to transport to the environmental testing laboratory.

Bore Hole Abandonment. Onshore borings were grouted to the surface with cement-bentonite grout following completion of the drilling and sampling effort. The borings performed in pavement areas were topped with an asphalt patch. We note that the grouted drillholes could settle with time and that the property owners should check and refill the borings, as necessary.

The drill cuttings, drill mud, and excess grout were drummed, labeled, and placed near their respective drillhole locations for disposal at a location selected by POLA. Samples of the drill cuttings were collected from the cuttings generated from the ground surface down to about 15-foot depth in the two land borings (DWP-B1 and DWP-B7). The samples, which were refrigerated following their collection, were transported to the analytical chemistry laboratory under chain-of-custody.

On completion of boring DWP-B6, the bore hole (with casing in place) was grouted to the wharf deck, and the casing was cut at the deck level and covered with a metal cap provided by the welders. On completion of the drilling and sampling of the four offshore borings, the drill casing was removed from the drillhole and the cuttings were allowed to settle on the harbor bottom.

Survey. A Differential Global Positioning System (DGPS) and integrated navigation software, owned and operated by Fugro, were used to position vessels over offshore exploration locations and to determine final X-Y coordinates for those locations. The DGPS also was used to position the barge's anchors. Coordinates calculated from Fugro's DGPS system are considered accurate to within about 3 to 5 feet.

The approximate locations of onshore explorations were established by tape measurement from existing features (e.g., buildings, fences, railroad tracks) that are shown on a map provided by POLA. Coordinates were then estimated from the plotted boring locations.

Boring Logs. Logs for the seven borings excavated for this study are presented as Plates A-2 through A-8. The boring logs indicate the approximate distribution of geologic materials beneath the ground surface or mudline at each exploration location. The logs also indicate sample type, blow counts, and pertinent laboratory test data. A key to the various terms and symbols used on the logs is presented as Plate A-12.

Vibrocore Explorations

A total of seven vibrocores were performed along the alignment of the pipeline on April 9 and April 25, 1997. As shown on Plate 2, the vibrocores were located beyond the edges of the navigation channel that were sampled as a part of the Main Channel Deepening Program. Three vibrocores were located in the vicinity of the toe of the dike along the Berth 150 shoreline in front of the Unocal terminal on the north side of the navigation channel, and four vibrocores were located near the toe of the dike near Berth 225 on the southeast side of the navigation channel. Details of the vibrocore system and field operations are provided below. The vibrocores were advanced to depths of approximately 9.5 to 19 feet below the existing mudline.

Vessel and Navigation. The vibrocore sampling activities were conducted from Kinnetic Laboratories' dedicated sampling vessel, the *R/V D.W. Hood,* which is about 32 feet long and custom outfitted for vibrocore sampling and other oceanographic work. The vessel's features include a hydraulic system with winches, capstan, A-frame, and boom.

A DGPS owned and operated by Kinnetic Laboratories was used to position the vessel over vibrocore locations and to determine final X-Y coordinates for each vibrocore performed. Coordinates calculated from the DGPS are considered accurate to within about 10 to 15 feet.

Water Depth Measurement. Water depths at exploration locations were measured with a sounding line (i.e., weighted tape measure) prior to deploying the vibrocorer. The measured water depths were corrected to MLLW tidal datum using predicted tide tables reported to the nearest quarter-hour for the POLA Inner Harbor. Relative to the harbor bottom elevations, we have assumed an error bar of about ±1 foot.

Sampling Equipment. The vibrocore sampling operations used a vibrohead and core barrel assemblies. The vibrohead was a 6-horsepower electric vibrohead with two contra-rotating vibrators capable of supplying a variable centrifugal force of between 0 and 11,000 pounds. It had a weight in air of about 450 pounds and measured about 36x22x14 inches. A gasoline generator on the vessel provided power to the vibrohead.

The core barrel assembly used for vibrocore sampling consisted of an aluminum core barrel and a stainless steel sampler shoe and catcher. The aluminum core barrels had an outside diameter of 4 inches and an inside diameter of about 3.87 inches.

Vibrocore Sampling Procedures. The first step in the vibrocore sampling process was to locate the target location and to position the vessel in its general vicinity. Two or three anchors were deployed and used to position the vessel over the designated sampling locations.

After setting anchors and positioning over a designated location, the water depth was measured and the vibrocoring equipment was assembled. To assemble the vibrocore equipment, a sampler shoe with a sample catcher attached to it was connected to an unlined, aluminum core barrel. Core barrels ranged in length from about 10 to 20 feet. After the core barrel was prepared, the vibrohead was winched into location over the stern of the vessel and the core barrel was attached to the vibrohead. Using a cable and winch system attached to the A-frame, the vibrocore assembly subsequently was lowered into the water until the leading edge of the core barrel contacted the harbor bottom sediments.

The vibrohead was then engaged and the core barrel was driven into the sediment using dead weight and vibratory action of the vibrohead. A tape measure attached to the vibrohead was used to monitor total penetration and rate of penetration. The estimated penetration rates are shown on the stratigraphic logs for the vibrocores. Once full penetration or refusal was reached, the system was shut off, extracted from the bottom, winched to the water surface, and the core barrel disconnected. The actual length of recovered sediments in the core barrel was then measured with a tape measure.

If the vibrocorer penetration was less than expected or if unacceptable sediment recovery occurred during the first deployment of the vibrocorer, the vibrocorer was deployed a second time in an effort to achieve greater penetration and sediment recovery.

Handling and Processing of Vibrocore Samples. For the DWP pipeline vibrocores, the core barrels were capped and labeled after they were retrieved onto the vessel, and subsequently were transported to land for further processing. The materials within the core barrels were extruded using vibratory techniques, and the exposed sediments were described and logged by a Fugro engineer without significant disturbance to the materials.

Following initial geotechnical logging, samples for environmental testing were selected by Kinnetic Laboratories. The environmental sediments selected by Kinnetic Laboratories were mixed to provide a homogeneous sample for environmental testing. These homogeneous samples from the vibrocores were combined to provide composite samples that represent the sediments above and beyond the limits of the POLA Channel Deepening Program sampling. In addition, a discrete subsample was taken from each core location.

Following environmental sampling, "geotechnical" subsamples of the remaining portions of each core were chosen and packaged by Fugro's engineer and transported to our Ventura laboratory for geotechnical testing. More detailed geotechnical logging of the observed materials was also performed at this time.

Vibrocore DWP-V7 was performed only to obtain additional material for environmental testing. Since the entire core barrel was retained by Kinnetic Laboratories for environmental testing, detailed geotechnical logging of this vibrocore sample, and collection of geotechnical samples was not possible.

Presentation of Results. Logs of the vibrocores performed along the alignment of the pipeline are provided on Plates A-9 through A-11. Plate A-12 provides a key to the terms and symbols used on the vibrocore logs. Additionally, logs of 11 vibrocores performed within 500 feet of the proposed alignment as a part of the Channel Deepening Program are provided on Plates C-1 through C-11 of Appendix C - Additional Field Exploration Data.

Location	DWP-B1	DWP-B2	DWP-B3	DWP-B4	DWP-B5	DWP-B6	DWP-B7
Date Drilled	5/1/97	4/27/97	4/22/97	4/23/97	4/25/97	5/2/97	5/2/97
Location							
North	4,023,270	4,023,071	4,022,489	4,022,048	4,021,419	4,021,012	4,020,948
East	4,205,465	4,205,402	4,205,567	4,205,859	4,206,176	4,206,358	4,206,404
Surface Elevation	+12.0	-38.6	-51.2	-50.4	-47.4	-17.5	+15.0
Final Drilling Depth	31.5	66.5	41.0	43.5	54.5	53.5	30.5
Bottom Elevation	-19.5	-105.1	-92.2	-93.9	-101.9	-71.0	-15.5
Depth to Water	8.0	--	--	--	--	--	11.0

Location	DWP-V1	DWP-V2	DWP-V3	DWP-V4	DWP-V5	DWP-V6
Date Drilled	4/9/97	4/9/97	4/9/97	4/9/97	4/9/97	4/9/97
Location						
North	4,023,081	4,023,063	4,023,033	4,021,083	4,021,062	4,021,051
East	4,205,407	4,205,417	4,205,421	4,206,317	4,206,317	4,206,337
Surface Elevation	-36.2	-40.9	-41.3	-47.4	-46.3	-38.2
Final Drilling Depth	19.0	15.0	15.5	9.5	9.5	18.0
Bottom Elevation	-55.2	-55.9	-56.8	-56.9	-55.8	-56.2
Water Depth	40.1	44.1	43.9	50.0	48.5	39.3

EXPLORATION SUMMARY
DWP - Reclaimed Water Pipeline
Port of Los Angeles

PLATE A-1

FUGRO

COORDINATES: N 4,023,270 E 4,205,465

ELEVATION: 12.0 ft (re. MLLW)

SAMPLE NO.	SAMPLER BLOWCOUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
		Fine to medium SAND with silt (SP-SM): medium dense, light gray, dry, with shells and scattered gravel							
1	(56)	- fine sand with silt and fine gravel and scattered 3/4" diameter crushed rock to 2' - fill to about 10'	115	102	13				
2	(39)	- with abundant shell fragments at 5'	116	98	18				
3	(65)	- fine grained, medium gray, moist to wet, at 8'	121	90	34	10			
4	(49)		128	102	26				
5	(48)	Silty fine SAND (SM): medium dense to dense, gray, with abundant shells and mica	125	98	28				
6	9	- loose to medium dense, dark gray, at 20'			24	25			
7	(19)	- interbedded with dark gray lean clay (CL) 25' to 26'	119	91	31	48	22	1	
8	(51)	- dense below 30'	123	96	28				

COMPLETION DEPTH: 31-1/2 ft
DEPTH TO WATER: 8.0 ft
BACKFILLED WITH: Drill Hole Cuttings
DRILLING DATE: May 1, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B1
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B001
61217ON(61217)
06/19/97\12:09

COORDINATES: N 4,023,071 E 4,205,402

ELEVATION: -38.6 ft MLLW (Based on water depth and tide)

Sample No.	Samplers	Sampler Blowcount	Material Description	Unit Wet Weight, pcf	Unit Dry Weight, pcf	Water Content, %	% Passing #200 Sieve	Liquid Limit, %	Plasticity Index, %	Su, ksf
			Sandy lean CLAY (CL): very soft, dark gray, with mica							
1		push		112	75	49				t0.15
				105	68	55		44	20	t0.05
			Silty fine SAND (SM): dense, tan, with mica							
2		push	- fine sand with silt (SP-SM) to 9'	117	91	28	11			
				128	106	20				
3		push		122	97	26	32			
4		(47)	- with light gray lean clay layers and brown streaks below 12.5'	129	104	24				p2.5 t1.7
5		(50/ 4")	Fine SAND with silt (SP-SM): very dense, light gray, with rusty brown streaks, abundant mica	126	98	28	7			
6		(50/ 4")	- with light gray sandy lean clay (CL) pockets and yellow streaks 19' to 21'	125	99	27				
7		81								
8		(ref/ 6")		127	102	25				
9		50/6"	- with shells at 33.5'							
10		43	- silty to clayey fine sand (SM-SC), light brownish gray, below 38'			30	21			

COMPLETION DEPTH: 66-1/2 ft
WATER DEPTH: 38.5 ft @ 0815 (Tide 0.0 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 27, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B2
DWP - Reclaimed Water Pipeline
Port of Los Angeles

June 1997

Project No. 96-42-1217

COORDINATES: N 4,023,071 E 4,205,402

ELEVATION: -38.6 ft MLLW (Based on water depth and tide)

ELEVATION, ft	DEPTH, ft	SAMPLE NO.	SAMPLER BLOWCOUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
-80				Sandy lean CLAY (CL): very stiff, light grayish brown, with abundant mica, rusty streaks							
		11	(59)		123	94	31		46	19	t2
-85	45			Silty fine SAND (SM): dense to very dense, light gray, with mica - with sandy silt seams to 53'							
		12	35				30	23			
-90	50										
		13	(?)								
-95	55										
-100	60										
		14	50/6"								
-105	65										
-110	70										
-115	75										

COMPLETION DEPTH: 66-1/2 ft
WATER DEPTH: 38.5 ft @ 0815 (Tide 0.0 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 27, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B2

DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B002
61217OFF(61217)
06/19/97\12:12

PLATE A-3b

COORDINATES: N 4,022,489 E 4,205,567

ELEVATION: -51.2 ft MLLW (Based on water depth and tide)

MATERIAL DESCRIPTION

Fine SAND with silt (SP-SM) to Silty fine SAND (SM): dense, light brown, with mica
- with shell fragments to 6'
- with silt pockets, seams, and layers (to 3" thick), red streaks and iron staining, 3' to 12'
- gray 12' to 33'
- very dense below 24'
- with silt seams and layers below 29'

SAMPLE NO.	SAMPLER BLOWCOUNT
1	(42)
2	push
3	push
4	push
5	push
6	push
7	push
8	push
9	push
10	push
11	push
12	push
13	50/4"
14	(50/ 5")
15	(50/ 6")

UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
128	101	27	13			
129	110	17				
131	102	28	11			
128	99	30	63			
136	112	22				
133	109	22	47			
131	110	19	38			
		24	9			
129	105	24				
125	97	29				
116	93	25				
127	100	27				

Elevation scale: -55, -60, -65, -70, -75, -80, -85, -90; Depth scale: 5, 10, 15, 20, 25, 30, 35

COMPLETION DEPTH: 41 ft
WATER DEPTH: 54.5 ft @ 0745 (Tide +3.5 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 22, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B3
DWP - Reclaimed Water Pipeline
Port of Los Angeles

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOWCOUNT	COORDINATES: N 4,022,489 E 4,205,567 ELEVATION: -51.2 ft MLLW (Based on water depth and tide) MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
			16		78/ 11"	Sandy lean CLAY (CL): very stiff to hard, dark gray, with sand seams			40				
-95	45												
-100	50												
-105	55												
-110	60												
-115	65												
-120	70												
-125	75												
-130													

COMPLETION DEPTH: 41 ft
WATER DEPTH: 54.5 ft @ 0745 (Tide +3.5 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 22, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B3
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B003
61217OFF(61217)
06/19/97\12:13

FUGRO

COORDINATES: N 4,022,048 E 4,205,859

ELEVATION: -50.4 ft MLLW (Based on water depth and tide)

ELEVATION, ft	DEPTH, ft	SAMPLE NO.	SAMPLER BLOWCOUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
		1	(18)	Silty fine SAND (SM): medium dense to dense, light gray, with silt layers and seams, and mica	123	98	25 25	65			
		2	push	- with coarse sand layers (2" to 4" thick) 1.5' to 5'	133	107	24	37			
-55	5	3	push	- with lean clay layers (4" to 6" thick) 5' to 6.5'			23 26	78	37	20	
		4	push								
		5	(80)	Silty, fine to coarse SAND (SM) to SAND with silt (SP-SM): dense to very dense, light gray, with fine gravel and coarse sand seams and layers, and mica, and shell fragments	132	111	19				
-60	10	6	push	- well graded to 15'	135	116	16	13			
		7	push	- with silt pockets and sandy silt layers below 11'	136	112	21				
		8	60		129	109	18 25	24 24			
-65	15	9	push	- sandy silt layers and silty clay pockets 12.5' to 13.5			19				
		10	(50/ 5")		125	106	19	5			
		11	push	Silty fine SAND (SM): dense to very dense, light gray, with mica and iron staining	133	113	17	14			
-70	20										
-75	25	12	77				23				
-80	30	13	(88/ 11")				28				
-85	35	14	50/6"				29				
-90		15	(64)	Lean CLAY (CL): very stiff, dark gray, with					43	16	

COMPLETION DEPTH: 43-1/2 ft
WATER DEPTH: 51 ft @ 0610 (Tide 0.6 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 23, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B4
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B004
61217OFF(61217)
06/19/97\12:14

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOWCOUNT	COORDINATES: N 4,022,048 E 4,205,859 ELEVATION: -50.4 ft MLLW (Based on water depth and tide) MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
						mica			30				
-95	45												
-100	50												
-105	55												
-110	60												
-115	65												
-120	70												
-125	75												
-130													

COMPLETION DEPTH: 43-1/2 ft
WATER DEPTH: 51 ft @ 0610 (Tide 0.6 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 23, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B4
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B004
61217OFF(61217)
06/19/97\12:14

COORDINATES: N 4,021,419 E 4,206,176

ELEVATION: -47.4 ft MLLW (Based on water depth and tide)

MATERIAL DESCRIPTION

Elevation scale (ft): -50, -55, -60, -65, -70, -75, -80, -85
Depth scale (ft): 5, 10, 15, 20, 25, 30, 35

Silty fine SAND (SM) to Sandy SILT (ML): loose, light gray, with silt seams, shell fragments, and mica
- fine gravel and shells to 0.2'

Fat CLAY (CH): very stiff, brown, blocky, with silty sand pockets, organics, and rust streaks
- sandy to 7.5'
- fine to coarse sand with silt (SW-SM), gray, with shells and mica, 7.5' to 8.5'

Fine to coarse SAND with silt and gravel (SW-SM): dense to very dense, light gray, with silt seams and pockets, shell fragments, and mica

- interbedded with silty fine sand (SM) layers (6" to 18" thick) below 14.5'

- shell layer at 18'
- abundant shells below 18'

- cobbles at 21'

Clayey, fine to medium SAND (SC): very dense, brownish gray, with mica and rust staining

SAMPLE NO.	SAMPLER BLOWCOUNT	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
1	push	133	106	25	7			
2	push	137	109	26	55			
3	push	136	116	16				
4	(52)	127	101	26 28	47	69	49	u3
5	push	126	105	20				
6	push	132	104	20 26		58	43	u4
7	(43)			23	11			
8	push			25 18	12			
9	push			22 20	38			
10	push			18	5			
11	(69)	129	106	22				
12	push			30				
13	(90/ 11")	129	108	20	5			
14	67			21				
15	(50/ 5")	134	112	19	25			
16	(77)	134	113	18				

COMPLETION DEPTH: 54-1/2 ft
WATER DEPTH: 49.5 ft @ 0930 (Tide 2.1 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 25, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B5

DWP - Reclaimed Water Pipeline
Port of Los Angeles

FUGRO

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOWCOUNT	COORDINATES: N 4,021,419 E 4,206,176 ELEVATION: -47.4 ft MLLW (Based on water depth and tide) MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
						Clayey, fine to medium SAND (SC): very dense, brownish gray, with mica and rust staining							
-90			17		50/6"				27				
	45												
-95													
	50												
-100			18		50/6"	- with gravel at 53'			25				
	55												
-105													
	60												
-110													
	65												
-115													
	70												
-120													
	75												
-125													

COMPLETION DEPTH: 54-1/2 ft
WATER DEPTH: 49.5 ft @ 0930 (Tide 2.1 ft)
BACKFILLED WITH: N/A
DRILLING DATE: April 25, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B5
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B005
61217OFF(61217)
06/19/97\12:16

FUGRO

COORDINATES: N 4,021,012 E 4,206,358

ELEVATION: -17.5 ft MLLW (Based on Wharf Deck El. +15)

SAMPLE NO.	SAMPLER BLOWCOUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
		Fine to coarse GRAVEL (GP) "quarry run" with clayey sand: black							
	0"/ 18"								
1	(38)	Sandy lean CLAY (CL) to Clayey SAND (SC): stiff to medium dense, black			51	52			
		- 3" diameter rock at 4.5'							
		Silty fine SAND (SM): medium dense to dense, dark gray, with abundant shells and mica							
2	(33)		125	98	28	47	NP	NP	
3	(50)	- with sand with silt (SP-SM) layers at 12.5'	126	98	29				
NR	(34)								
4	(28)	Fat CLAY (CH): stiff to very stiff, brown, with shell	131	110	19		52	34	u2.7
5	(45)	- stiff, light to medium gray, with coarse sand, at 22.5'	128	110	16	37			
		Silty fine SAND (SM): medium dense to dense, light brown mottled light gray, with mica							
6	25				21	27			
7	(60)	- interbedded lean clay (CL), stiff, greenish brown, 32' to 33'			23				
			119	98	21				
NR	51								

COMPLETION DEPTH: 53-1/2 ft
WATER DEPTH: 16 ft @ 0800 (Tide 3 ft)
BACKFILLED WITH: Drill Hole Cuttings
DRILLING DATE: May 2, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B6
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B006
61217OFF(61217)
06/19/97\12:17

FUGRO

COORDINATES: N 4,021,012 E 4,206,358

ELEVATION: -17.5 ft MLLW (Based on Wharf Deck El. +15)

ELEVATION, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE NO.	SAMPLERS	SAMPLER BLOWCOUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
						Silty fine SAND (SM): medium dense to dense, light brown mottled light gray, with mica							
-60			8		85	- very dense, light gray, with mica, below 42' - fine sand with silt (SP-SM) at 42.5			26	10			
	45												
-65						- sandy clay (SC) at 47'							
			9		(50/ 4")		136	115	19	57			
	50												
-70			10		50/6"				24	29			
	55												
-75													
	60												
-80													
	65												
-85													
	70												
-90													
	75												
-95													

COMPLETION DEPTH: 53-1/2 ft
WATER DEPTH: 16 ft @ 0800 (Tide 3 ft)
BACKFILLED WITH: Drill Hole Cuttings
DRILLING DATE: May 2, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B6
DWP - Reclaimed Water Pipeline
Port of Los Angeles

UGIS ID: FF97B006
61217OFF(61217)
06/19/97\12:17

COORDINATES: N 4,020,948 E 4,206,404

ELEVATION: 15.0 ft (re. MLLW)

ELEVATION, ft	DEPTH, ft	SAMPLE NO.	SAMPLER BLOWCOUNT	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	Su, ksf
				Asphalt; 4"							
				Aggregate base; 6"							
		1	(37)	Silty, fine to coarse SAND (SM) (Fill): medium dense, light gray, with shells and wood debris	114	109	16 5				
10	5	2	(31)	- fine grained, with gravel, at 5.7'	131	112	17	20			
		3	(21)	- scattered shells at 8'	130	110	18				
5	10	4	(7/3")	- light to medium gray, with riprap, at 11'	125	102	23				
0	15	5	(15)	- fine grained, olive gray, trace mica, at 14'	118	87	35				
-5	20	6	17	Fine SAND with silt (SP-SM): medium dense to dense, dark gray - wood fragments at 19'			30	10			
-10	25	7	(50)		125	98	28				
-15	30	8	55	- fine to medium grained, dense to very dense, medium gray, with shell fragments, below 29'			23				
-20	35										

COMPLETION DEPTH: 30-1/2 ft
DEPTH TO WATER: 11.0 ft
BACKFILLED WITH: Drill Hole Cuttings
DRILLING DATE: May 2, 1997

DRILLING METHOD: Wet Rotary
DRILLED BY: Pitcher Drilling
LOGGED BY: CDPrentice
CHECKED BY: TWMcNeilan

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF BORING NO. DWP-B7

DWP - Reclaimed Water Pipeline
Port of Los Angeles

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION
			LOCATION: N 4,023,081 E 4,205,407
			ELEVATION: -36.2 ft (re: MLLW; based on water depth of 40.1 ft and tide of 3.9 ft)
		1	CLAY with sand (CL): very soft to soft, dark gray, with mica
-38	2		- becomes soft with shell fragments at 1.5'
-40	4	2	- 3" brownish yellow, silty, fine to medium sand seam, at 3.25'
-42			- brownish yellow silt (ML) layer at 4.75' to 5.75'
	6	3	Fine to medium SAND with silt (SP-SM): brownish yellow, with mica, some iron staining
-44	8		
-46	10	4	- decreasing silt content at 9.25'
-48	12	5	
-50	14	6	
-52	16	7	- reddish brown bands at 16.5'
-54	18	8	- shell fragments at 16.75' - 2" olive gray to gray silt seam at 17' - gray silt seam at 17.75' - increasing silt content (~50% fines) at 18'
-56	20		

CORE RATE, ft/min (5, 10, 15, 20) | WATER CONTENT, % | % PASSING #200 SIEVE | LIQUID LIMIT, % | PLASTICITY INDEX, %

PENETRATION DEPTH: 19.0 ft
RECOVERY LENGTH: 19.0 ft
DATE OF EXPLORATION: April 9, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Vibrocore
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. DWP-V1

UGIS ID: FF97V001

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION
			LOCATION: N 4,023,063 E 4,205,417
			ELEVATION: -40.9 ft (re: MLLW; based on water depth of 44.1 ft and tide of 3.2 ft)
-42		1	CLAY with sand (CL): very soft to soft, dark olive gray, with mica and petroleum deposits
	2		- becomes soft at 1.5'
-44			
-46	4	2	Silty fine SAND (SM): dark olive gray, with mica and shell fragments - increasing silt content at 5.25'
-48	6	3	Fine to medium SAND (SP): yellowish brown
-50	8	4	- with reddish brown and gray bands, at 8'
-52	10		- becomes medium grained at 10' - 5" light gray silt layer at 10.25' - interlayered with light gray silt seams at 10.9' to 11.25'
-54	12	5	Silty fine SAND (SM): light brown, with mica
-56	14	6, 7	- with reddish brown and gray bands at 13' to 13.5' - increasing silt content at 13.5' - becomes light gray with decreasing silt content at 14' - gray silt pocket, 1" in width, at 14.1'
-58	16		
-60	18		
	20		

CORE RATE, ft/min (5, 10, 15, 20) | WATER CONTENT, % | % PASSING #200 SIEVE | LIQUID LIMIT, % | PLASTICITY INDEX, %

PENETRATION DEPTH: 15.0 ft
RECOVERY LENGTH: 14.8 ft
DATE OF EXPLORATION: April 9, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Vibrocore
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. DWP-V2

UGIS ID: FF97V002

LOGS OF VIBROCORES
DWP - Reclaimed Water Pipeline

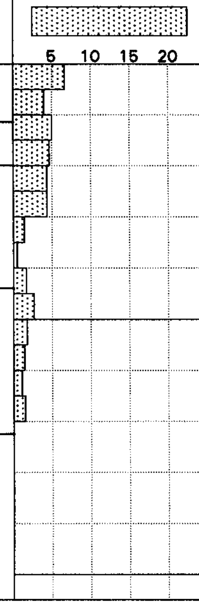
June 1997
Project No. 96-42-1217

LOCATION: N 4,023,033 E 4,205,421

ELEVATION: -41.3 ft (re: MLLW; based on water depth of 43.9 ft and tide of 2.6 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
-42		1	CLAY with sand (CL): very soft to soft, dark gray, with mica, some organics and petroleum deposits				
-44	2	2	- 4" cobble at 1.75'				
			Silty fine SAND (SM): dark gray to gray, with mica and shell fragments, interlayered with dark gray silt				
-46	4	3	Silty fine SAND (SM) to Sandy SILT (ML): very soft to soft, dark gray, with light brown silt chunks				
-48	6		- decreasing sand content at 5'				
-50	8		- 3.5" cobble at 8.5'				
-52	10	4	Silty fine SAND (SM): brown to light brown, with mica				
-54	12	5	- some gray streaks at 12.5' to 15.5'				
-56	14	6	- increasing silt content at 15'				
-58	16						
-60	18						
	20						

CORE RATE, ft/min



PENETRATION DEPTH: 15.5 ft
RECOVERY LENGTH: 15.5 ft
DATE OF EXPLORATION: April 9, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Vibrocore
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. DWP-V3

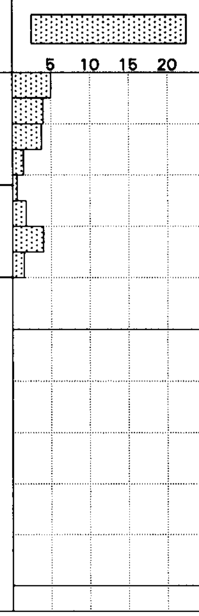
UGIS ID: FF97V003

LOCATION: N 4,021,083 E 4,206,317

ELEVATION: -47.4 ft (re: MLLW; based on water depth of 50.0 ft and tide of 2.6 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
-48		1	CLAY with sand (CL): very soft to soft, dark gray, with mica				
-50	2						
-52	4		- intermixed with olive gray silt from 4' to 4.4'				
-54	6	2	SILT with sand (ML): light brown, intermixed with concretions and gravel/rock 1" to 2" diameter				
			- less gravel/rocks at 7'				
-56	8	3		29	73		
-58	10						
-60	12						
-62	14						
-64	16						
-66	18						
	20						

CORE RATE, ft/min



PENETRATION DEPTH: 9.5 ft
RECOVERY LENGTH: 9.5 ft
DATE OF EXPLORATION: April 9, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Vibrocore
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. DWP-V4

UGIS ID: FF97V004

LOGS OF VIBROCORES

DWP - Reclaimed Water Pipeline

61212VIB (61217)
06/19/97 01:40PM

LOG OF VIBROCORE NO. DWP-V5

LOCATION: N 4,021,062 E 4,206,317

ELEVATION: -46.3 ft (re: MLLW; based on water depth of 48.5 ft and tide of 2.2 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION
-48	2	1	CLAY with sand (CL): very soft to soft, dark olive gray, with mica
-50	4	2	Sandy lean CLAY (CL): light brown, intermixed with concretions - dark brown band at 4'
-52	6	3	
-54	8	4	Silty fine SAND (SM): light brown to brown, with mica - becomes silty fine sand (SM) to sandy silt (ML) at 7'
-56	10		
-58	12		
-60	14		
-62	16		
-64	18		
-66	20		

Column headings: ELEV, ft; DEPTH, ft; MATERIAL SYMBOL; SAMPLE; SAMPLE NUMBER; MATERIAL DESCRIPTION; CORE RATE, ft/min (5, 10, 15, 20); WATER CONTENT, %; % PASSING #200 SIEVE; LIQUID LIMIT, %; PLASTICITY INDEX, %

PENETRATION DEPTH: 9.5 ft
RECOVERY LENGTH: 9.5 ft
DATE OF EXPLORATION: April 9, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Vibrocore
REVIEWED BY: SGSukiasian

UGIS ID: FF97V005

LOG OF VIBROCORE NO. DWP-V6

LOCATION: N 4,021,051 E 4,206,337

ELEVATION: -38.2 ft (re: MLLW; based on water depth of 39.3 ft and tide of 1.1 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION
-40	2	1	CLAY (CL): very soft to soft, dark gray, with mica
-42	4	2	- 1" gray silty fine sand seam at 4.5' Sandy lean CLAY (CL): brown to light brown - intermixed with concretions at 6' to 12.75'
-44	6		
-46	8	3	
-48	10	4	SILT with fine sand (ML): brown to light brown
-50	12		
-52	14	5	Silty, fine to medium SAND (SM): yellowish brown, with mica and dark gray bands
-54	16	6	
-56	18		
-58	20		

Column headings: ELEV, ft; DEPTH, ft; MATERIAL SYMBOL; SAMPLE; SAMPLE NUMBER; MATERIAL DESCRIPTION; CORE RATE, ft/min (5, 10, 15, 20); WATER CONTENT, %; % PASSING #200 SIEVE; LIQUID LIMIT, %; PLASTICITY INDEX, %

PENETRATION DEPTH: 18.0 ft
RECOVERY LENGTH: 17.0 ft
DATE OF EXPLORATION: April 9, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Vibrocore
REVIEWED BY: SGSukiasian

UGIS ID: FF97V006

LOGS OF VIBROCORES
DWP - Reclaimed Water Pipeline

61212VIB (61217)
06/19/97 01:40PM

ELEVATION, ft	DEPTH, ft
-12	2
-14	4
-16	6
-18	8
-20	10
-22	12
-24	14
-26	16
-28	18
-30	20
-32	22
-34	24
-36	26
-38	28
-40	30
-42	32
-44	34
-46	36
-48	38

SAMPLE NO.	BLOWCOUNT / REC"/DRIVE"
1	25
2	(25)
3	(25)
4	(25)
5	18"/ 30"
6	
7	
8	20"/ 24"
9	(25)
10	30"/ 30"
11	20"/ 24"

LOCATION: The drill hole location referencing local landmarks or coordinates
SURFACE EL: Using local, MSL, MLLW or other datum

MATERIAL DESCRIPTION	
Well graded GRAVEL (GW)	COARSE GRAINED
Poorly graded GRAVEL (GP)	COARSE GRAINED
Well graded SAND (SW)	COARSE GRAINED
Poorly graded SAND (SP)	COARSE GRAINED
Clayey SAND (SC)	COARSE GRAINED
Silty SAND (SM)	COARSE GRAINED
SAND with silt (SP-SM)	COARSE GRAINED
Fat CLAY (CH)	FINE GRAINED
Lean CLAY (CL)	FINE GRAINED
Silty CLAY (CL-ML)	FINE GRAINED
Elastic SILT (MH)	FINE GRAINED
SILT (ML)	FINE GRAINED
Clayey SILT (ML/CL)	FINE GRAINED
SANDSTONE	ROCK
SILTSTONE	ROCK
CLAYSTONE	ROCK
MUDSTONE	ROCK
GRANITE	ROCK
SHALE	ROCK
Paving and/or Base Materials	

General Notes

1 Soil Texture Symbol

2 Sloped line in symbol column indicates transitional boundary

3 Samplers and sampler dimensions (unless otherwise noted in report text) are as follows:

Symbol for:

1	SPT Sampler, driven 1 3/8" ID, 2" OD
2	CA Liner Sampler, driven 2 3/8" ID, 3" OD
3	CA Liner Sampler, disturbed 2 3/8" ID, 3" OD
4	Recovery Interval
5	Thin-walled Tube, pushed 2 7/8" ID, 3" OD
6	Bulk Bag Sample (from cuttings)
7	Hand Auger Sample
8	Rock Core Sample
9	No Sample Recovered
10	Vibracore Sample
11	Pitcher Sample

4 Sampler Driving Resistance

Number of blows with 140 lb. hammer, falling 30-in. to drive sampler 1-ft. after seating sampler 6-in.; for example,

Blows/ft	Description
25	25 blows drove sampler 12" after initial 6" of seating
86/11"	After driving sampler the initial 6" of seating, 36 blows drove sampler through the second 6" interval, and 50 blows drove the sampler 5" into the third interval
50/6"	50 blows drove sampler 6" after initial 6" of seating
Ref/3"	50 blows drove sampler 3" during initial 6" seating interval

5 Blow counts for California Liner Sampler shown in ( )

6 Length of sample symbol approximates recovery length

7 Classification of Soils per ASTM D2487 or D2488

8 Geologic Formation noted in bold font at the top of interpreted interval

9 Strength Legend

Q = Unconfined Compression
u = Unconsolidated Undrained Triaxial
t = Torvane
p = Pocket Penetrometer
m = Miniature Vane

10 Water Level Symbols

Initial or perched water level
Final ground water level
Seepages encountered

11 Rock Quality Designation (RQD) is the sum of recovered core pieces greater than 4 inches divided by the length of the cored interval

KEY TO TERMS & SYMBOLS USED ON LOGS

APPENDIX B
LABORATORY TESTING RESULTS

APPENDIX B
LABORATORY TESTING RESULTS

The purpose of the laboratory testing program was to evaluate relevant physical indices and engineering properties of subsurface materials. The primary objectives of the program were to:

- Classify and characterize sampled subsurface materials;
- Evaluate the existing in situ conditions; and
- Evaluate relevant strength properties of specified subsurface materials.

To meet these objectives, various tests were performed on selected samples. Test types are generally grouped into four categories: classification and index tests, moisture content and density estimates, compressibility tests, and strength tests.

Classification and index tests were performed on both driven and push samples. Density evaluations, compressibility tests, and strength tests were typically performed only on relatively undisturbed push and sleeve samples.

The numbers of the various tests conducted for the City of Los Angeles Department of Water and Power (DWP) pipeline project are listed below:

Laboratory Test	Number of Tests	ASTM Test Designation
Atterberg Limits	9	D4318
Sieve Analysis	20	D422
Hydrometer Analysis	0	D422
Percent Passing No. 200 Sieve	22	D1140
Total and Dry Densities	58	D2937
Unconsolidated-Undrained Triaxial Compression	3	D2850
Miniature Vane	0	D4648
Direct Shear	2	D3080
Consolidation (Incremental Controlled Stress)	2	D2435
Corrosion	3	
Resistivity		G-57
pH		Caltrans No. 643
Chloride and Sulfate		EPA 600/4-79-020
Moisture Content	35	D2216

[1] ASTM (1995)

Factual laboratory test results are tabulated or presented graphically in this appendix. A tabular summary of all laboratory tests performed for the project is presented on Plate B-1. Various laboratory test results also are tabulated versus depth on the individual drillhole and vibrocore logs, Plates A-2 through A-11 of Appendix A - Field Exploration Data. Test results that cannot be conveniently tabulated or plotted versus depth on logs also are provided in this appendix. Test results in this category include: grain-size curves, plasticity charts, direct shear, unconsolidated-undrained triaxial, corrosion, and consolidation test results. Results of these tests are presented on Plates B-2 through B-6.

LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B1 / 1 / 3.0	Fine to medium SAND with silt (SP-SM)	115	102	13														T
DWP-B1 / 2 / 5.7	Fine to medium SAND with silt (SP-SM)	116	98	18														T
DWP-B1 / 3 / 8.8	Fine SAND with silt (SP-SM)	121	90	34	10								480	10.75	217	229		T, S, Co
DWP-B1 / 4 / 11.8	Fine SAND with silt (SP-SM)	128	102	26														T
DWP-B1 / 5 / 14.8	Silty fine SAND (SM)	125	98	28														T
DWP-B1 / 6 / 20.0	Silty fine SAND (SM)			24	25													M, FC
DWP-B1 / 7 / 25.6	Clayey SAND (SC)	119	91	31	48	22	1											T, A, FC
DWP-B1 / 8 / 30.7	Silty fine SAND (SM)	123	96	28														T

Classification Tests
UWW = Unit Wet Weight
UDW = Unit Dry Weight
MC = Moisture Content
Fines = % passing #200 Sieve
LL = Liquid Limit
PI = Plasticity Index

Compressive Strength Tests
CU = Consolidated Undrained
QU = Unconfined Compression
UU = Unconsolidated Undrained
TV = Torvane
PP = Pocket Penetrometer
MV = Miniature Vane

Corrosivity Tests
R = Resistivity, ohm-cm, satur.
pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
M = Moisture Content
T = Total & Dry Density
S = Grain Size Analysis
H = Hydrometer
A = Atterberg Limits
FC = Percent <#200 Sieve
D = Direct Shear
P = Compaction Test
CU = CU Triaxial
U = UU Triaxial
Co = Corrosivity Tests
k = Permeability Test

SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

LOCAT'N	SAMPLE NUMBER	DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B2	1	1.7	Sandy lean CLAY (CL)	112	75	49					0.15									T
DWP-B2	1	3.4	Sandy lean CLAY (CL)	105	68	55		44	20		0.05									T, A
DWP-B2	2	6.6	Fine SAND with silt (SP-SM)	117	91	28	11													T, S
DWP-B2	2	8.3	Fine SAND with silt (SP-SM)	128	106	20														T
DWP-B2	3	10.3	Silty fine SAND (SM)	122	97	26	32													T, FC
DWP-B2	4	12.9	Silty fine SAND (SM)								1.7	2.5								TV, PP
DWP-B2	4	13.7	Silty fine SAND (SM)	129	104	24														T
DWP-B2	5	15.8	Fine SAND with silt (SP-SM)	126	98	28	7						0.7	38						T, S, D
DWP-B2	6	19.5	Fine SAND with silt (SP-SM)	125	99	27														T
DWP-B2	8	28.8	Fine SAND with silt (SP-SM)	127	102	25														T
DWP-B2	10	38.3	Silty to Clayey fine SAND (SM-SC)			30	21													M, FC
DWP-B2	11	43.0	Sandy lean CLAY (CL)	123	94	31		46	19		2									T, A, C, TV
DWP-B2	12	47.8	Silty fine SAND (SM)			30	23													M, FC

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pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
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S = Grain Size Analysis
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FC = Percent <#200 Sieve
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U = UU Triaxial
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SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

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LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR c	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B3 / 1 / 1.0	Fine (w/a trace of coarse) SAND with silt (SP-SM)	128	101	27	13													T, S
DWP-B3 / 2 / 2.3	Fine SAND with silt (SP-SM) to Silty SAND (SM)	129	110	17														T
DWP-B3 / 4 / 4.0	Fine SAND with silt (SP-SM)	131	102	28	11						0.0	30						T, S, D
DWP-B3 / 5 / 5.5	Fine SAND with silt (SP-SM) to Silty SAND (SM)	128	99	30	63													T, FC
DWP-B3 / 6 / 7.8	Fine SAND with silt (SP-SM) to Silty SAND (SM)	136	112	22														T
DWP-B3 / 8 / 10.1	Silty fine SAND (SM)	133	109	22	47													T, S
DWP-B3 / 9 / 11.7	Fine SAND with silt (SP-SM) to Silty SAND (SM)	131	110	19	38													T, FC
DWP-B3 / 10 / 13.8	Fine SAND with silt (SP-SM) to Silty SAND (SM)			24	9													M, FC
DWP-B3 / 11 / 16.4	Fine SAND with silt (SP-SM) to Silty SAND (SM)	129	105	24														T
DWP-B3 / 12 / 18.4	Fine SAND with silt (SP-SM) to Silty SAND (SM)	125	97	29									108	7.8	621	4167		T, Co
DWP-B3 / 14 / 29.5	Fine SAND with silt (SP-SM) to Silty SAND (SM)	116	93	25														T
DWP-B3 / 15 / 35.4	Fine SAND with silt (SP-SM) to Silty SAND (SM)	127	100	27														T
DWP-B3 / 16 / 40.1	Fine SAND with silt (SP-SM) to Silty SAND (SM)			40														M

Classification Tests
UWW = Unit Wet Weight
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Compressive Strength Tests
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QU = Unconfined Compression
UU = Unconsolidated Undrained
TV = Torvane
PP = Pocket Penetrometer
MV = Miniature Vane

Corrosivity Tests
R = Resistivity, ohm-cm, satur.
pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
M = Moisture Content
T = Total & Dry Density
S = Grain Size Analysis
H = Hydrometer
A = Atterberg Limits
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U = UU Triaxial
Co = Corrosivity Tests
k = Permeability Test

SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B4 / 1 / 0.0	Sandy SILT (ML)	123	98	25	65													T, S
DWP-B4 / 1 / 0.8	Silty fine SAND (SM)			25														M
DWP-B4 / 2 / 2.6	Silty fine SAND (SM)	133	107	24	37													T, S
DWP-B4 / 3 / 4.0	Silty fine SAND (SM)			23														M
DWP-B4 / 3 / 4.8	Lean CLAY (CL)			26	78	37	20											M, A, FC
DWP-B4 / 4 / 7.6	Silty fine SAND (SM)	132	111	19														T
DWP-B4 / 5 / 9.0	Fine to coarse SAND (SW) with gravel and silt seams	135	116	16	13													T, S
DWP-B4 / 6 / 10.3	Silty, fine to coarse SAND (SM) to SAND with silt (SP-SM)	136	112	21														T
DWP-B4 / 7 / 11.8	Fine to coarse SAND (SW) with gravel and silt seams	129	109	18	24													T, S
DWP-B4 / 8 / 12.3	Silty fine (w/a trace of medium) SAND (SM)			25	24													M, S
DWP-B4 / 9 / 14.1	Silty, fine to coarse SAND (SM) to SAND with silt (SP-SM)			19														M
DWP-B4 / 10 / 15.8	Medium (w/fine) SAND with silt (SP-SM)	125	106	19	5													T, S
DWP-B4 / 11 / 17.8	Silty fine SAND (SM)	133	113	17	14													T, FC
DWP-B4 / 12 / 24.0	Silty fine SAND (SM)			23														M
DWP-B4 / 13 / 28.8	Silty fine SAND (SM)			28														M

Classification Tests
UWW = Unit Wet Weight
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PI = Plasticity Index

Compressive Strength Tests
CU = Consolidated Undrained
QU = Unconfined Compression
UU = Unconsolidated Undrained
TV = Torvane
PP = Pocket Penetrometer
MV = Miniature Vane

Corrosivity Tests
R = Resistivity, ohm-cm, satur.
pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
M = Moisture Content
T = Total & Dry Density
S = Grain Size Analysis
H = Hydrometer
A = Atterberg Limits
FC = Percent <#200 Sieve
D = Direct Shear
P = Compaction Test
CU = CU Triaxial
U = UU Triaxial
Co = Corrosivity Tests
k = Permeability Test

SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

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LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION						UNDRAINED SHEAR STRENGTHS			DIRECT SHEAR		CORROSIVITY TESTS				PERMEABILITY (k), cm/sec	TEST LISTING
	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UU ksf	TV ksf	PP ksf	C	Φ	R	pH	SO4	Cl		
DWP-B4 / 14 / 33.6	Silty fine SAND (SM)																M
			29														
DWP-B4 / 15 / 38.6	Lean CLAY (CL)																A
					43	16											
DWP-B4 / 15 / 39.6	Lean CLAY (CL)																M
			30														

Classification Tests
UWW = Unit Wet Weight
UDW = Unit Dry Weight
MC = Moisture Content
Fines = % passing #200 Sieve
LL = Liquid Limit
PI = Plasticity Index

Compressive Strength Tests
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QU = Unconfined Compression
UU = Unconsolidated Undrained
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PP = Pocket Penetrometer
MV = Miniature Vane

Corrosivity Tests
R = Resistivity, ohm-cm, satur.
pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
M = Moisture Content
T = Total & Dry Density
S = Grain Size Analysis
H = Hydrometer
A = Atterberg Limits
FC = Percent <#200 Sieve
D = Direct Shear
P = Compaction Test
CU = CU Triaxial
U = UU Triaxial
Co = Corrosivity Tests
k = Permeability Test

SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

LOCAT'N	SAMPLE NUMBER	DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B5	1	1.1	Silty fine SAND (SM) to Sandy SILT (ML)	133	106	25	7													T, FC
DWP-B5	2	3.0	Sandy SILT (ML)	137	109	26	55													T, S
DWP-B5	3	5.0	Fat CLAY (CH)	136	116	16														T
DWP-B5	4	6.3	Fat CLAY (CH)	127	101	26		69	49	3.0										T, A, U
DWP-B5	5	6.8	Faty CLAY (CH)			28	47													M, FC
DWP-B5	5	7.5	Fine to coarse SAND with silt (SW-SM)	126	105	20														T
DWP-B5	5	8.5	Fat CLAY (CH)			20														M
DWP-B5	6	9.1	Fat CLAY (CH)	132	104	26		58	43	4.0										T, A, U
DWP-B5	7	11.5	Fine to coarse SAND with silt (SW-SM)			23	11													M, S
DWP-B5	8	12.8	Fine to coarse SAND with silt and gravel (SW-SM)			25														M
DWP-B5	8	13.0	Fine to coarse SAND with silt and gravel (SW-SM)			18	12													M, FC
DWP-B5	9	14.5	Fine to coarse SAND with silt and gravel (SW-SM)			22														M
DWP-B5	9	15.3	Fine to coarse SAND with silt and gravel (SW-SM)			20	38													M, FC
DWP-B5	10	16.4	Fine to coarse SAND with silt (SW-SM)			18	5													M, S
DWP-B5	10	17.0	Fine to coarse SAND with silt and gravel (SW-SM)																	T

Classification Tests
UWW = Unit Wet Weight
UDW = Unit Dry Weight
MC = Moisture Content
Fines = % passing #200 Sieve
LL = Liquid Limit
PI = Plasticity Index

Compressive Strength Tests
CU = Consolidated Undrained
QU = Unconfined Compression
UU = Unconsolidated Undrained
TV = Torvane
PP = Pocket Penetrometer
MV = Miniature Vane

Corrosivity Tests
R = Resistivity, ohm-cm, satur.
pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
M = Moisture Content
T = Total & Dry Density
S = Grain Size Analysis
H = Hydrometer
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FC = Percent <#200 Sieve
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SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

FUGRO

LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B5 / 11 / 19.1	Fine to coarse SAND with silt and gravel (SW-SM)	129	106	22									128	7.64	707	4089		T, Co
DWP-B5 / 12 / 20.6	Fine to coarse SAND with silt and gravel (SW-SM)			30														M
DWP-B5 / 13 / 23.0	Fine to coarse SAND with silt and gravel (SW-SM)	129	108	20	5													T, FC
DWP-B5 / 14 / 27.1	Fine to coarse SAND with silt and gravel (SW-SM)			21														M
DWP-B5 / 15 / 32.5	Clayey, fine to medium SAND (SC)	134	112	19	25													T, FC
DWP-B5 / 16 / 38.2	Clayey, fine to medium SAND (SC)	134	113	18														T
DWP-B5 / 17 / 42.3	Clayey, fine to medium SAND (SC)			27														M
DWP-B5 / 18 / 52.4	Clayey, fine to medium SAND (SC)			25														M

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SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

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(07/18/97..12:11PM)

LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B6 / 1 / 4.0	Sandy lean CLAY (CL)			51	52													M, S
DWP-B6 / 2 / 9.2	Silty fine SAND (SM)	125	98	28	47	NP	NP											T, A, FC
DWP-B6 / 3 / 13.3	Silty fine SAND (SM)	126	98	29														T
DWP-B6 / 4 / 19.2	Fat CLAY (CH)	131	110	19		52	34	2.8	2.4									T, A, U, TV
DWP-B6 / 5 / 23.3	Fat CLAY (CH)	128	110	16	37				2.6									T, FC, TV
DWP-B6 / 6 / 27.5	Silty fine SAND (SM)			21	27													M, S
DWP-B6 / 7 / 32.5	Silty fine SAND (SM)			23														M
DWP-B6 / 7 / 33.5	Silty fine SAND (SM)	119	98	21														T
DWP-B6 / 8 / 42.5	Fine SAND with silt (SP-SM)			26	10													M, S
DWP-B6 / 9 / 47.7	Sandy CLAY (CL)	136	115	19	57													T, FC
DWP-B6 / 10 / 52.5	Silty fine SAND (SM)			24	29													M, FC

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SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UU ksf	TV ksf	PP ksf	C	Φ	R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-B7 / 1 / 2.0	Silty, fine to coarse SAND (SM)			16														M
DWP-B7 / 1 / 3.0	Silty, fine to coarse SAND (SM)	114	109	5														T
DWP-B7 / 2 / 5.7	Silty fine SAND (SM) with gravel	131	112	17	20													T, S
DWP-B7 / 3 / 8.7	Silty, fine to coarse SAND (SM)	130	110	18									180	7.98	646	2413		T, Co
DWP-B7 / 4 / 11.1	Silty, fine to coarse SAND (SM)	125	102	23														T
DWP-B7 / 5 / 15.3	Silty, fine to coarse SAND (SM)	118	87	35														T
DWP-B7 / 6 / 19.0	Fine SAND with silt (SP-SM)			30	10													M, S
DWP-B7 / 7 / 24.8	Fine SAND with silt (SP-SM)	125	98	28														T
DWP-B7 / 8 / 29.0	Fine to medium SAND with silt (SP-SM)			23														M

Column groups: SAMPLE DESCRIPTION (UWW, UDW, MC, FINES, LL, PI); UNDRAINED SHEAR STRENGTHS (UU, TV, PP); DIRECT SHEAR (C, Φ); CORROSIVITY TESTS (R, pH, SO4, Cl).

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pH = pH
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SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

LOCAT'N / SAMPLE NUMBER / DEPTH, ft	SAMPLE DESCRIPTION	UWW pcf	UDW pcf	MC %	FINES %	LL %	PI %	UNDRAINED SHEAR STRENGTHS UU ksf	TV ksf	PP ksf	DIRECT SHEAR C	Φ	CORROSIVITY TESTS R	pH	SO4	Cl	PERMEABILITY (k), cm/sec	TEST LISTING
DWP-V4	SILT with sand (ML)																	M, FC
3																		
7.5				29	73													

Classification Tests
UWW = Unit Wet Weight
UDW = Unit Dry Weight
MC = Moisture Content
Fines = % passing #200 Sieve
LL = Liquid Limit
PI = Plasticity Index

Compressive Strength Tests
CU = Consolidated Undrained
QU = Unconfined Compression
UU = Unconsolidated Undrained
TV = Torvane
PP = Pocket Penetrometer
MV = Miniature Vane

Corrosivity Tests
R = Resistivity, ohm-cm, satur.
pH = pH
Cl = Chloride, ppm
SO4 = Sulfate, ppm

Test Listing Abbreviations
M = Moisture Content
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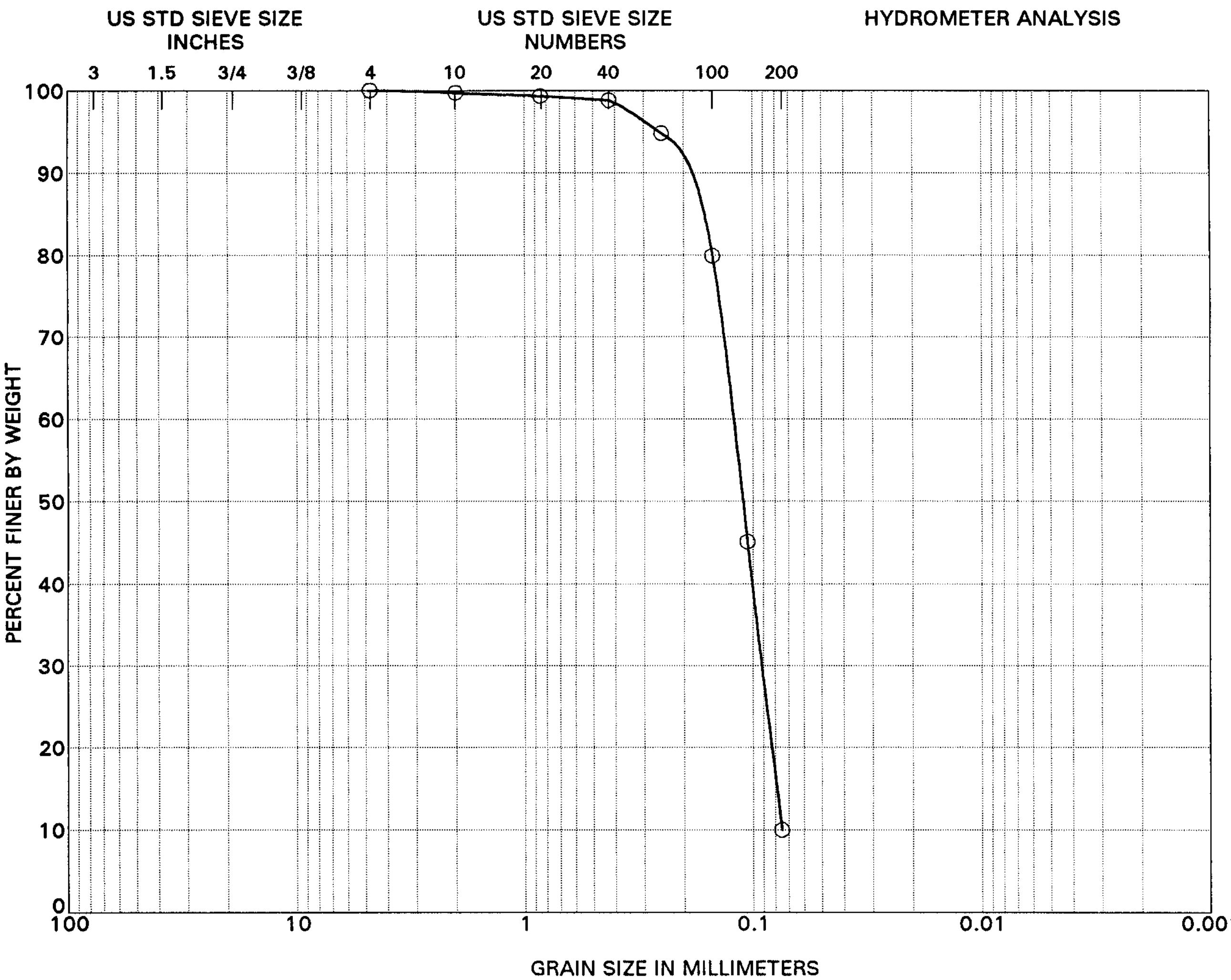
SUMMARY OF LABORATORY TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles



GRAVEL		SAND			SILT or CLAY
coarse	fine	coarse	medium	fine	

LEGEND (location)	(depth, ft)	CLASSIFICATION	Cc	Cu
○ DWP-B1	8.8	Fine SAND with silt (SP-SM)	0.9	1.6

GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles

GRAINSIZ(61217)
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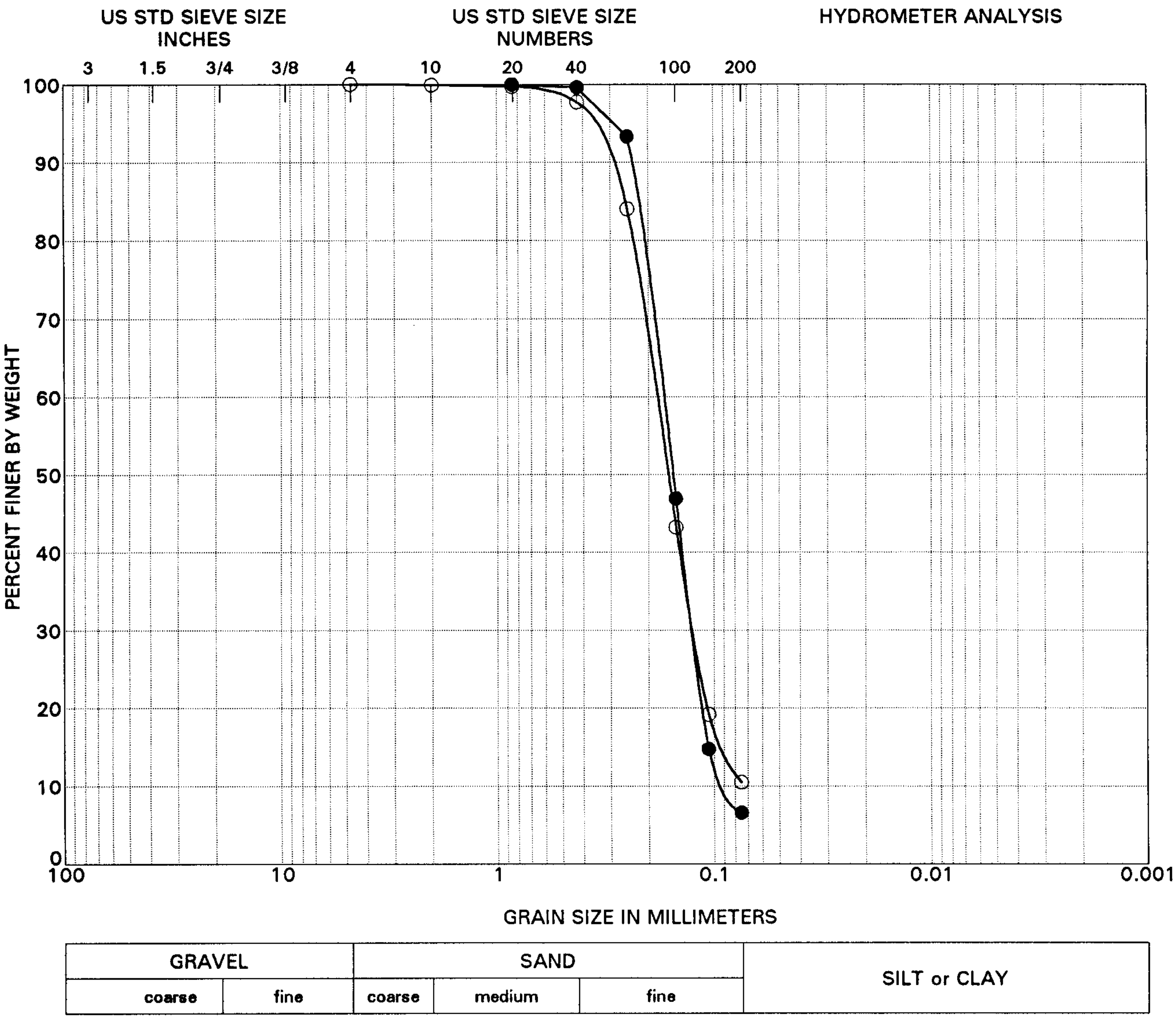
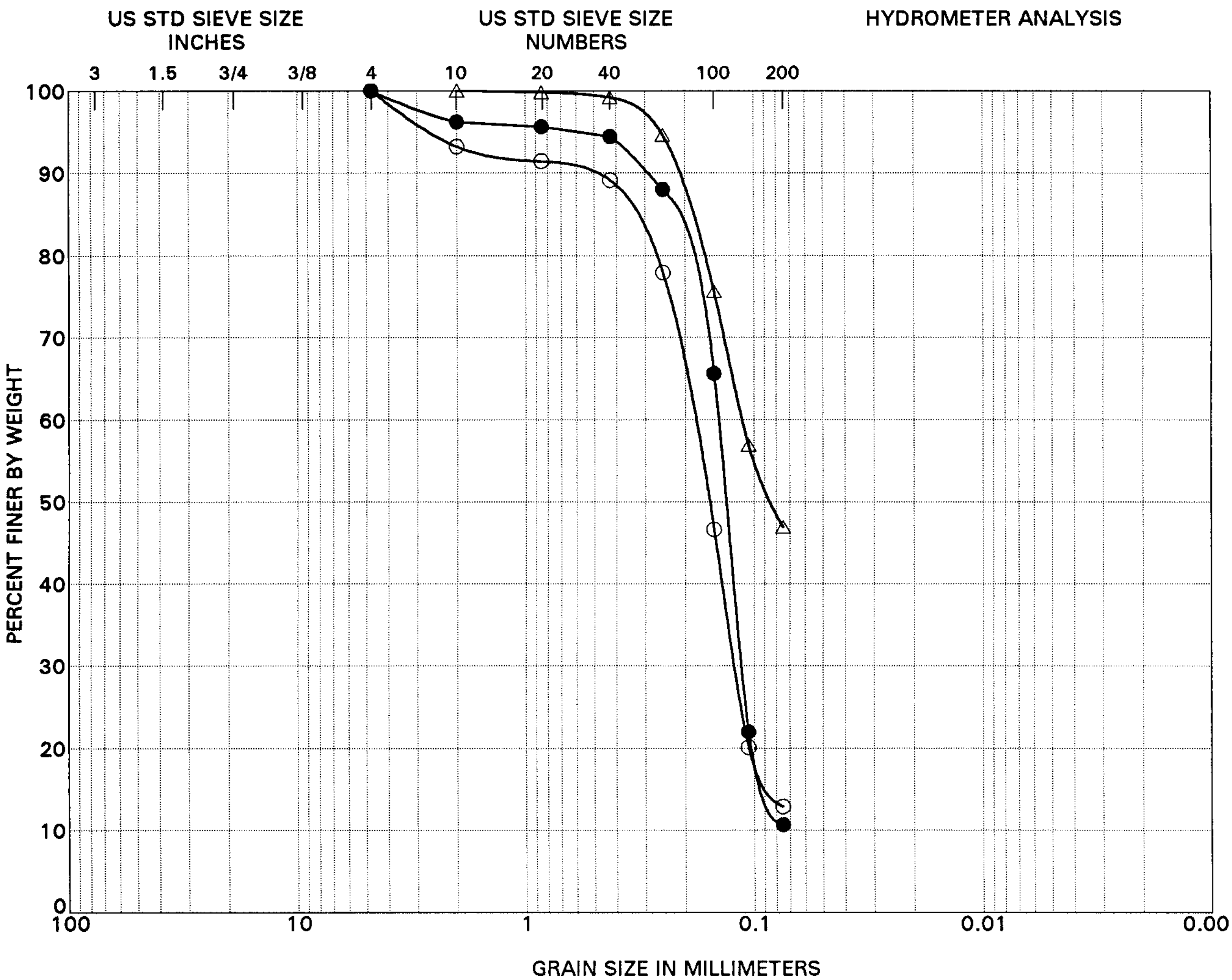


LEGEND (location)	(depth, ft)	CLASSIFICATION	Cc	Cu
○ DWP-B2	6.6	Fine SAND with silt (SP-SM)	1.2	2.6
● DWP-B2	15.8	Fine SAND with silt (SP-SM)	1.0	2.0

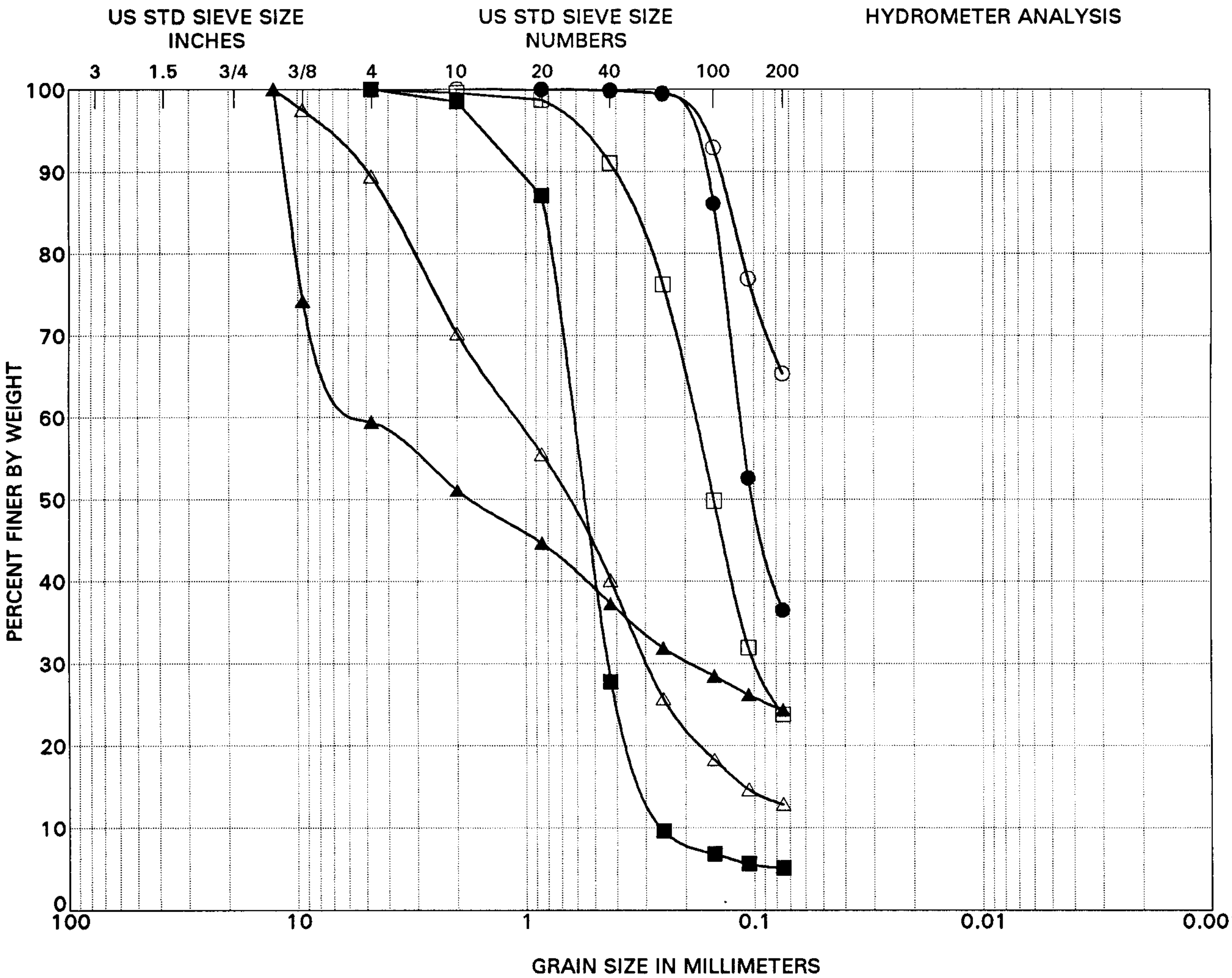
GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles



GRAVEL		SAND			SILT or CLAY
coarse	fine	coarse	medium	fine	

LEGEND (location)	(depth, ft)	CLASSIFICATION	Cc	Cu
○ DWP-B3	1.0	Fine (w/a trace of coarse) SAND with silt (SP-SM)		
● DWP-B3	4.0	Fine SAND with silt (SP-SM)	1.3	2.0
△ DWP-B3	10.1	Silty fine SAND (SM)		

GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles



GRAVEL		SAND			SILT or CLAY
coarse	fine	coarse	medium	fine	

LEGEND (location)		(depth,ft)	CLASSIFICATION	Cc	Cu
○	DWP-B4	0.0	Sandy SILT (ML)		
●	DWP-B4	2.6	Silty fine SAND (SM)		
△	DWP-B4	9.0	Fine to coarse SAND (SW) with gravel and silt seams		
▲	DWP-B4	11.8	Fine to coarse SAND (SW) with gravel and silt seams		
□	DWP-B4	12.3	Silty fine (w/a trace of medium) SAND (SM)		
■	DWP-B4	15.8	Medium (w/fine) SAND with silt (SP-SM)	1.2	2.4

GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles

GRAINSIZ(61217)
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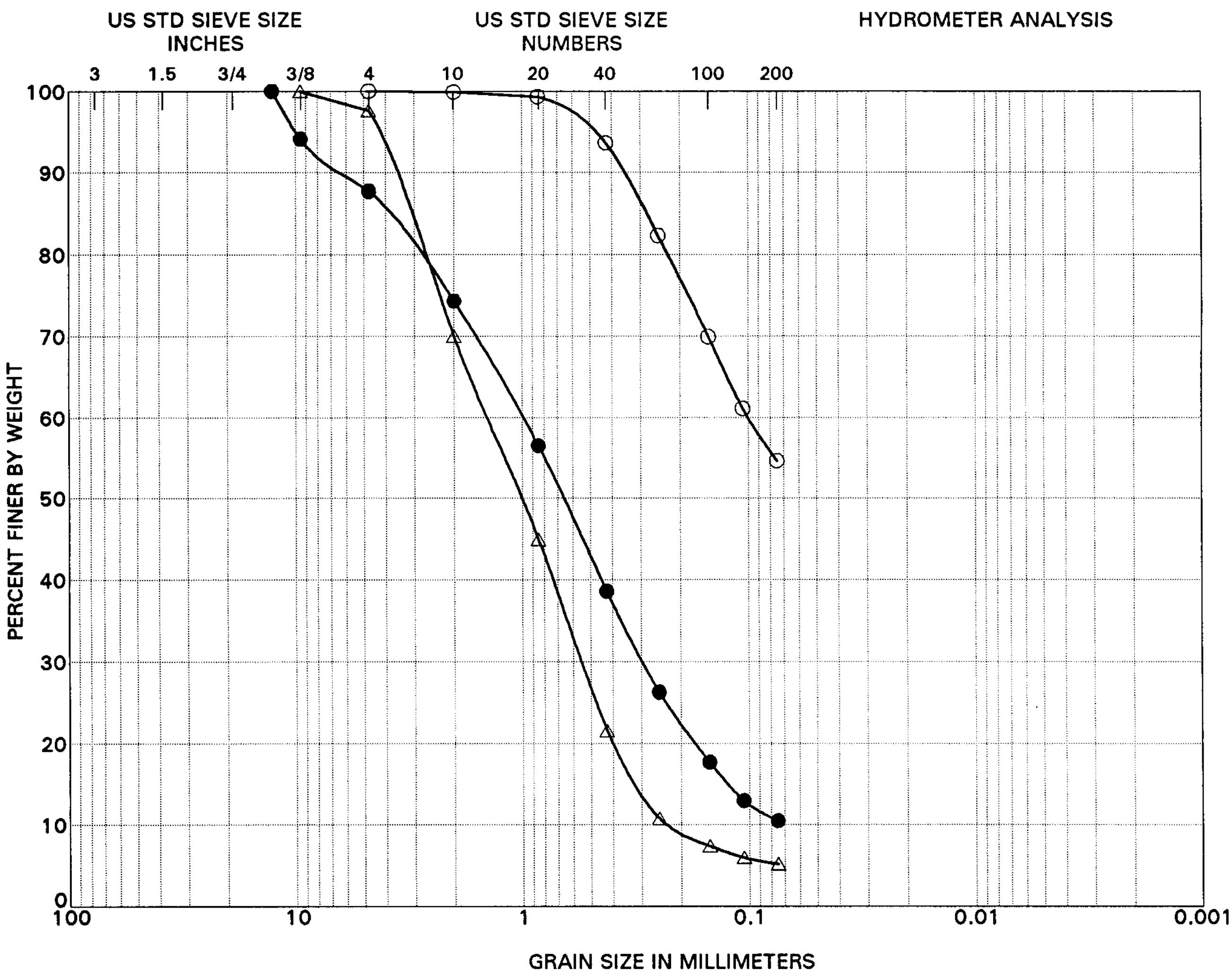
PLATE B-2d



GRAVEL		SAND			SILT or CLAY
coarse	fine	coarse	medium	fine	

LEGEND (location)	(depth, ft)	CLASSIFICATION	Cc	Cu
○ DWP-B5	3.0	Sandy SILT (ML)		
● DWP-B5	11.5	Fine to coarse SAND with silt (SW-SM)	1.2	14.4
△ DWP-B5	16.4	Fine to coarse SAND with silt (SW-SM)	0.9	6.4

GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles

PLATE B-2e

GRAINSIZ(61217)
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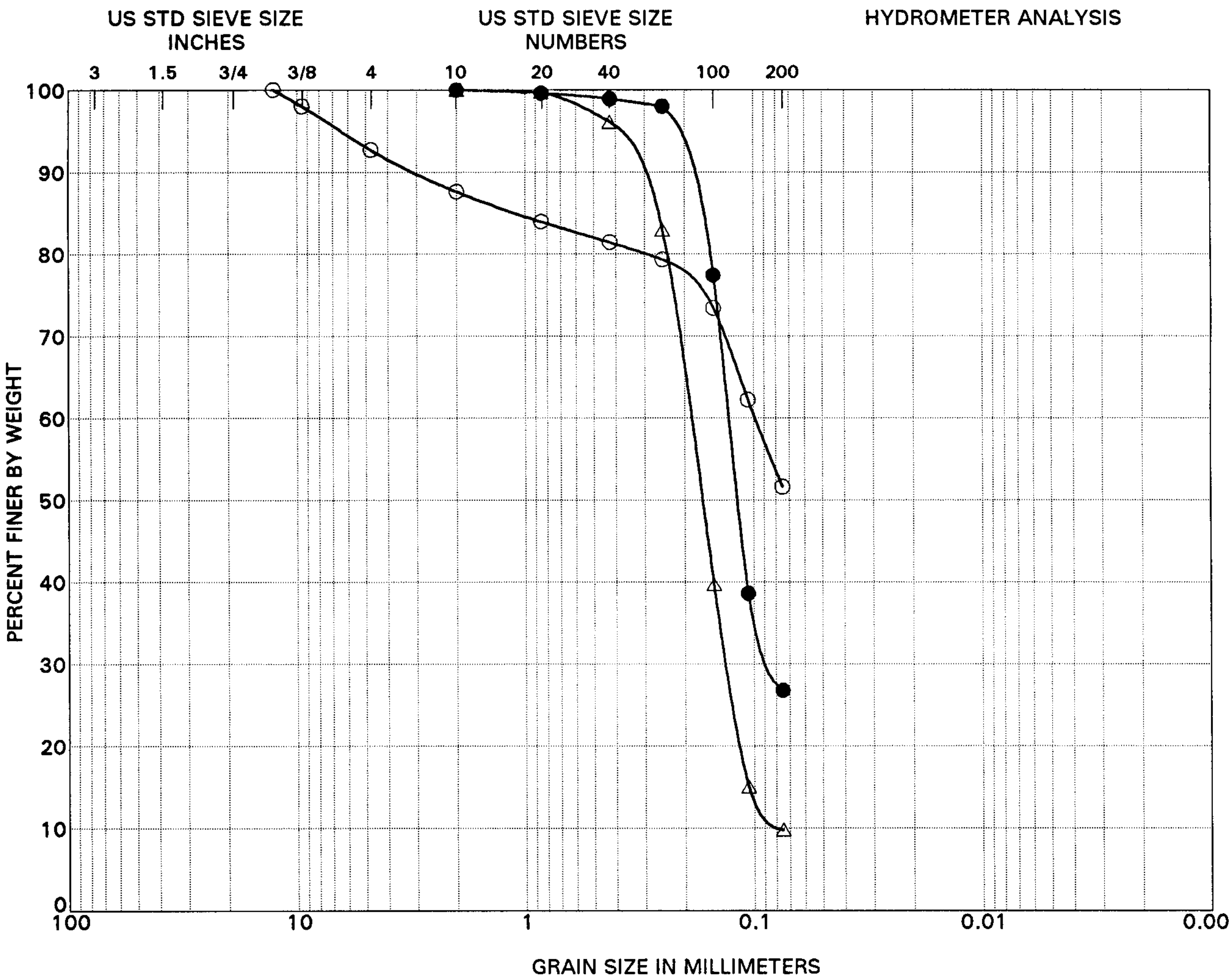
June 1997
Project No. 96-42-1217



GRAVEL		SAND			SILT or CLAY
coarse	fine	coarse	medium	fine	

LEGEND (location)	(depth,ft)	CLASSIFICATION	Cc	Cu
○ DWP-B6	4.0	Sandy lean CLAY (CL)		
● DWP-B6	27.5	Silty fine SAND (SM)		
△ DWP-B6	42.5	Fine SAND with silt (SP-SM)	1.2	2.5

GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles

PLATE B-2f

GRAINSIZ(61217)
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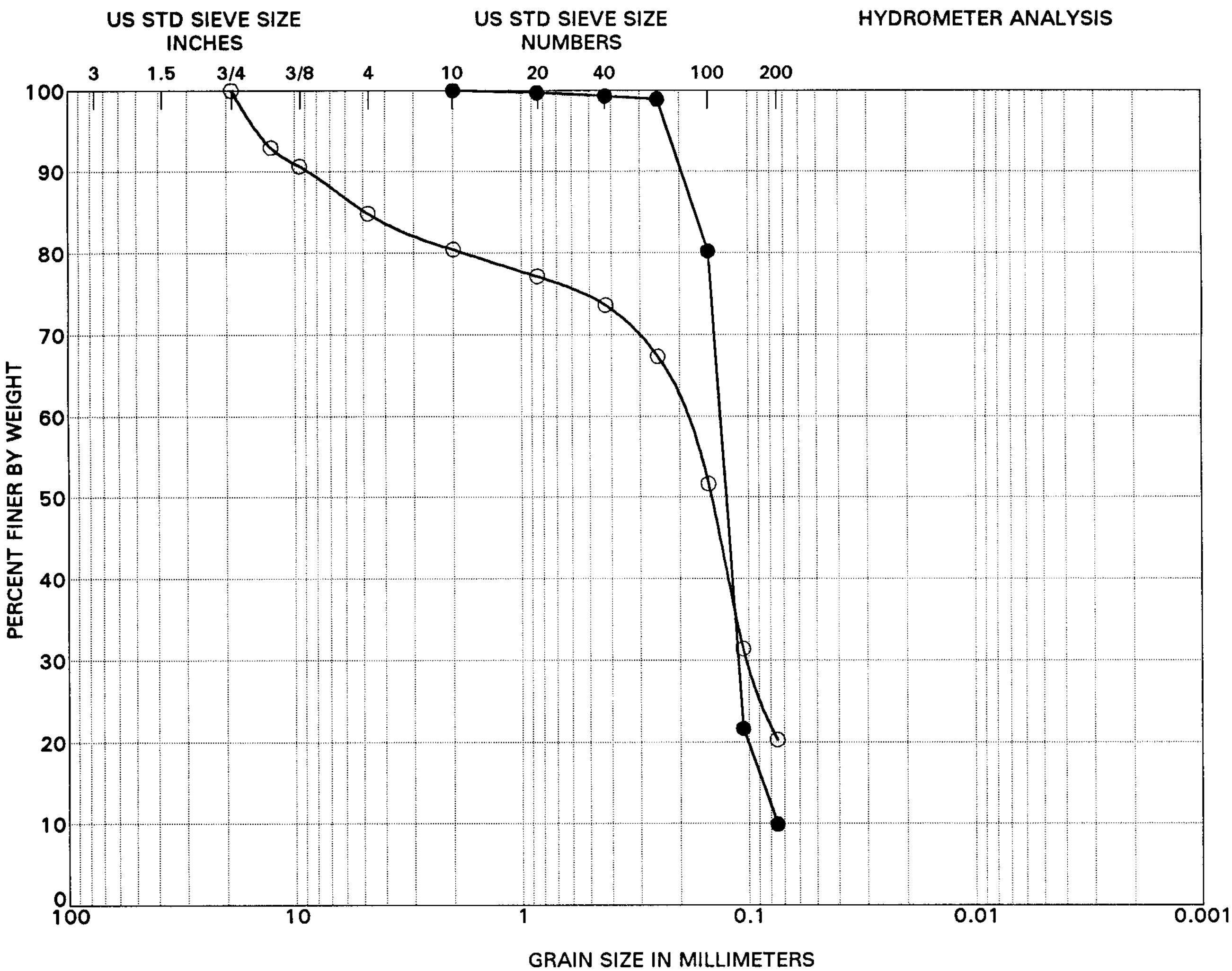
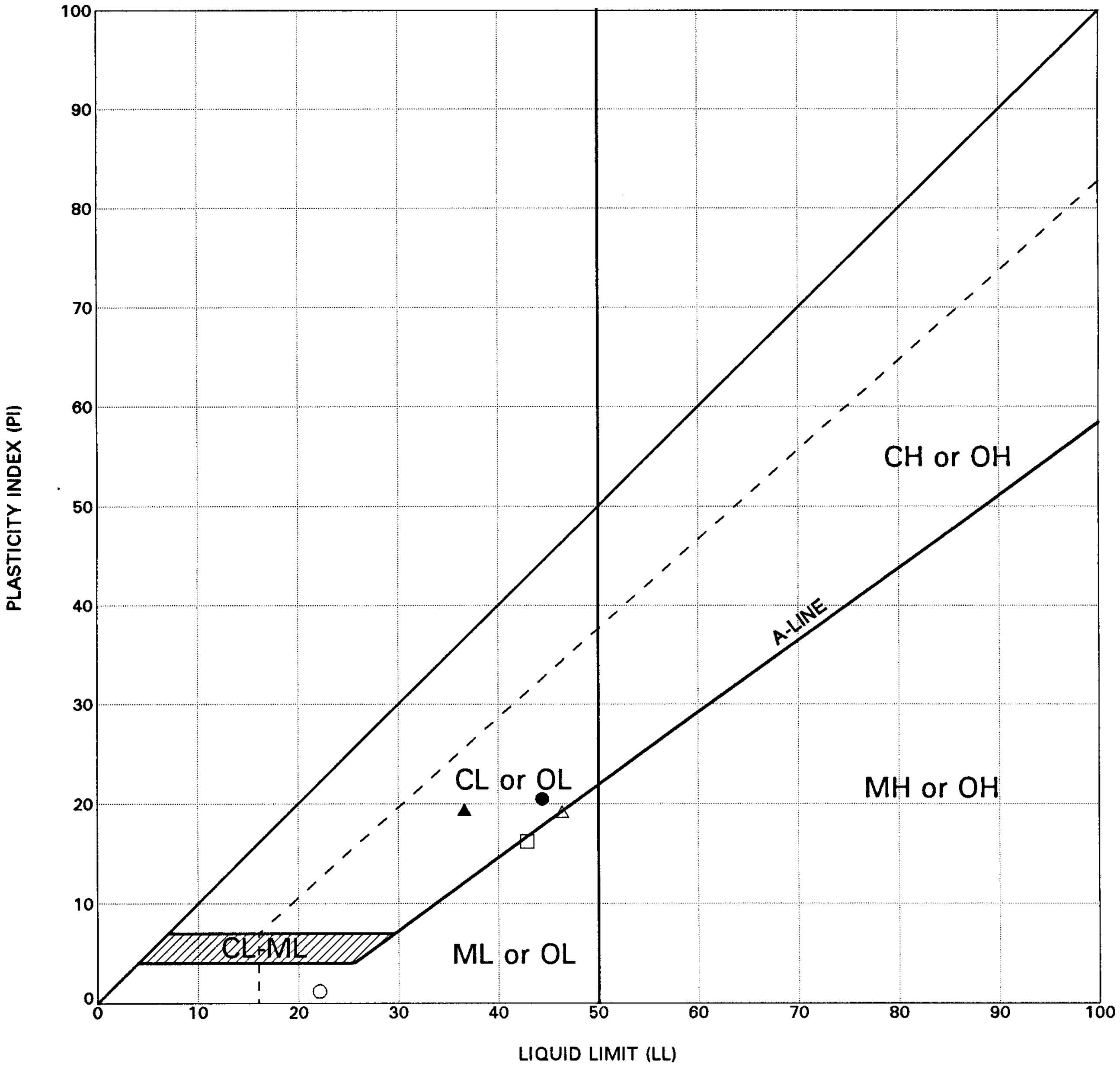


GRAVEL		SAND			SILT or CLAY
coarse	fine	coarse	medium	fine	

LEGEND (location)	(depth,ft)	CLASSIFICATION	Cc	Cu
○ DWP-B7	5.7	Silty fine SAND (SM) with gravel		
● DWP-B7	19.0	Fine SAND with silt (SP-SM)	1.2	1.8

GRAIN SIZE CURVES
DWP - Reclaimed Water Pipeline
Port of Los Angeles



LEGEND (location)	(depth, ft)	CLASSIFICATION	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)
○ DWP-B1	25.6	Clayey SAND (SC)	22	21	1
● DWP-B2	3.4	Sandy lean CLAY (CL)	44	24	20
△ DWP-B2	43.0	Sandy lean CLAY (CL)	46	27	19
▲ DWP-B4	4.8	Lean CLAY (CL)	37	17	20
□ DWP-B4	38.6	Lean CLAY (CL)	43	27	16

ATTERBERG LIMITS TEST RESULTS

PLASTICITY CHART
DWP - Reclaimed Water Pipeline
Port of Los Angeles

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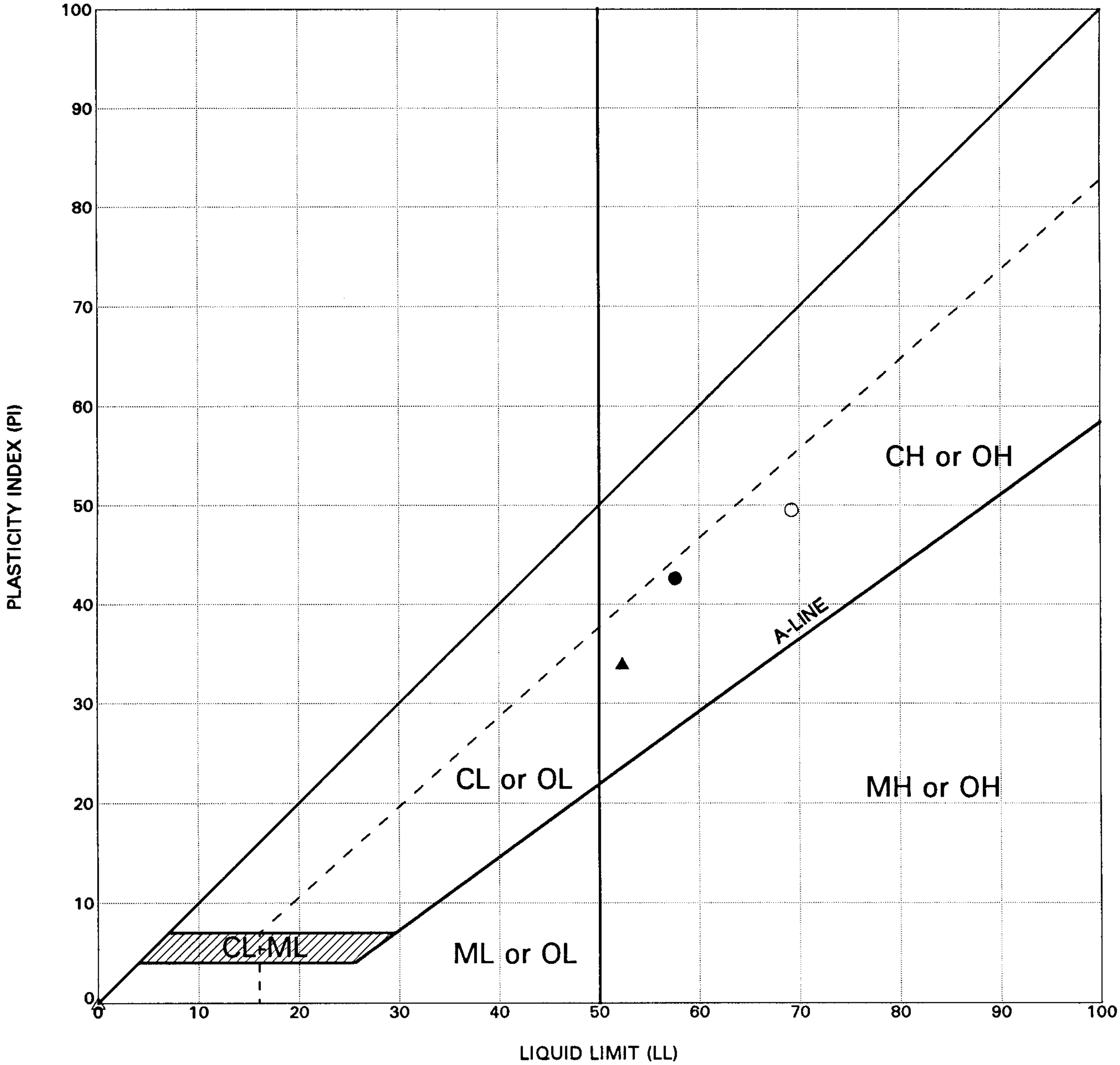
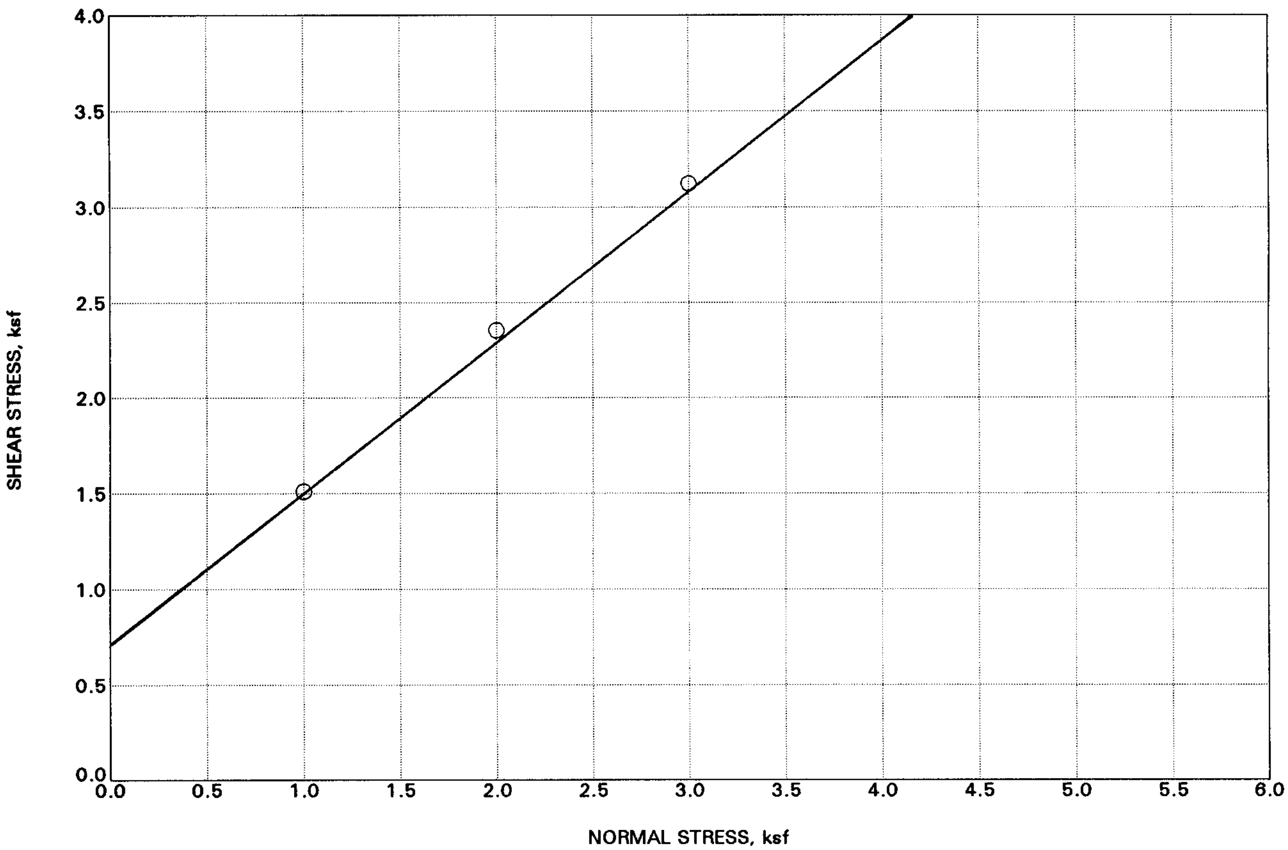


ATTERBERG LIMITS TEST RESULTS

LEGEND (location)	(depth, ft)	CLASSIFICATION	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)
○ DWP-B5	6.3	Fat CLAY (CH)	69	20	49
● DWP-B5	9.1	Fat CLAY (CH)	58	15	43
△ DWP-B6	9.2	Silty fine SAND (SM)	NP	NP	NP
▲ DWP-B6	19.2	Fat CLAY (CH)	52	18	34

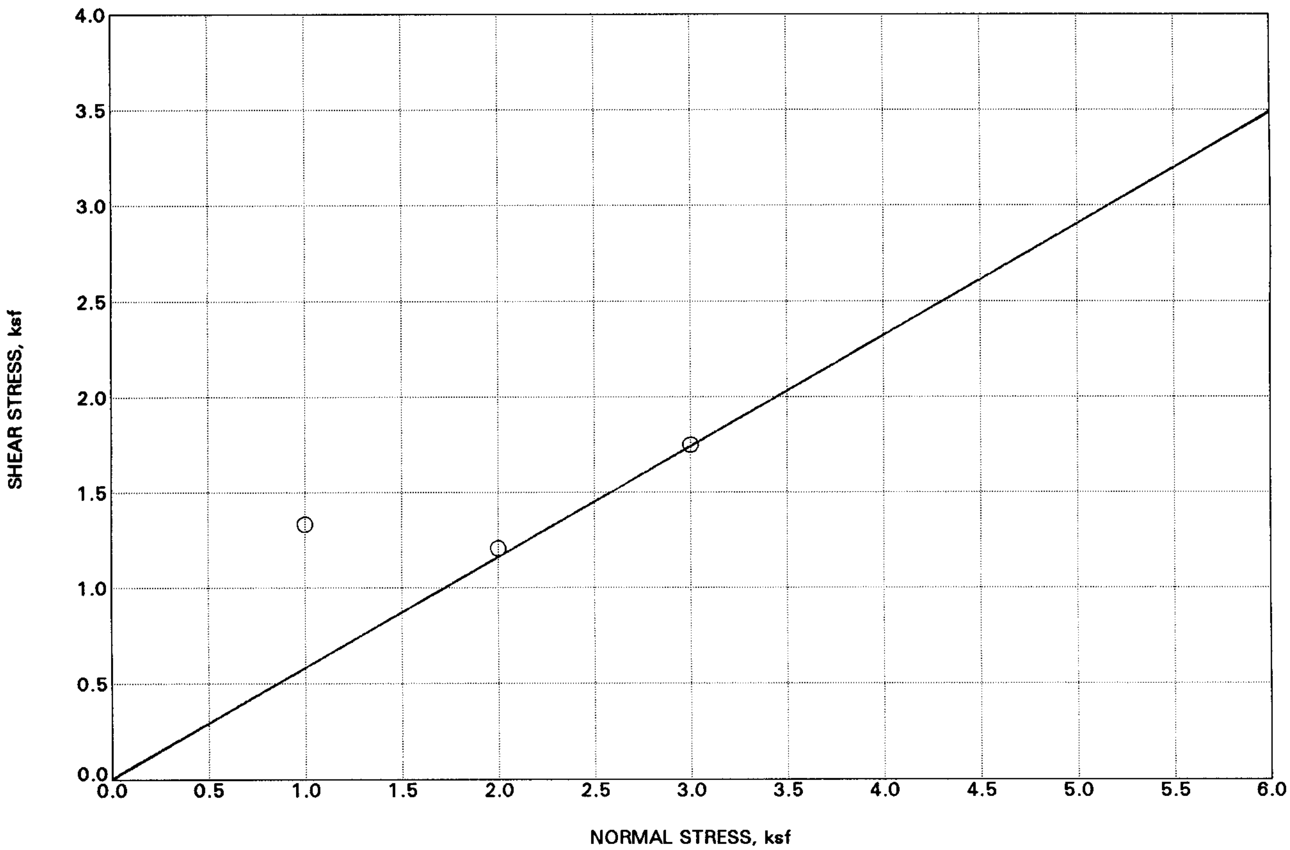
PLASTICITY CHART
DWP - Reclaimed Water Pipeline
Port of Los Angeles



EFFECTIVE COHESION, ksf	0.70
EFFECTIVE ANGLE OF INTERNAL FRICTION, deg	38

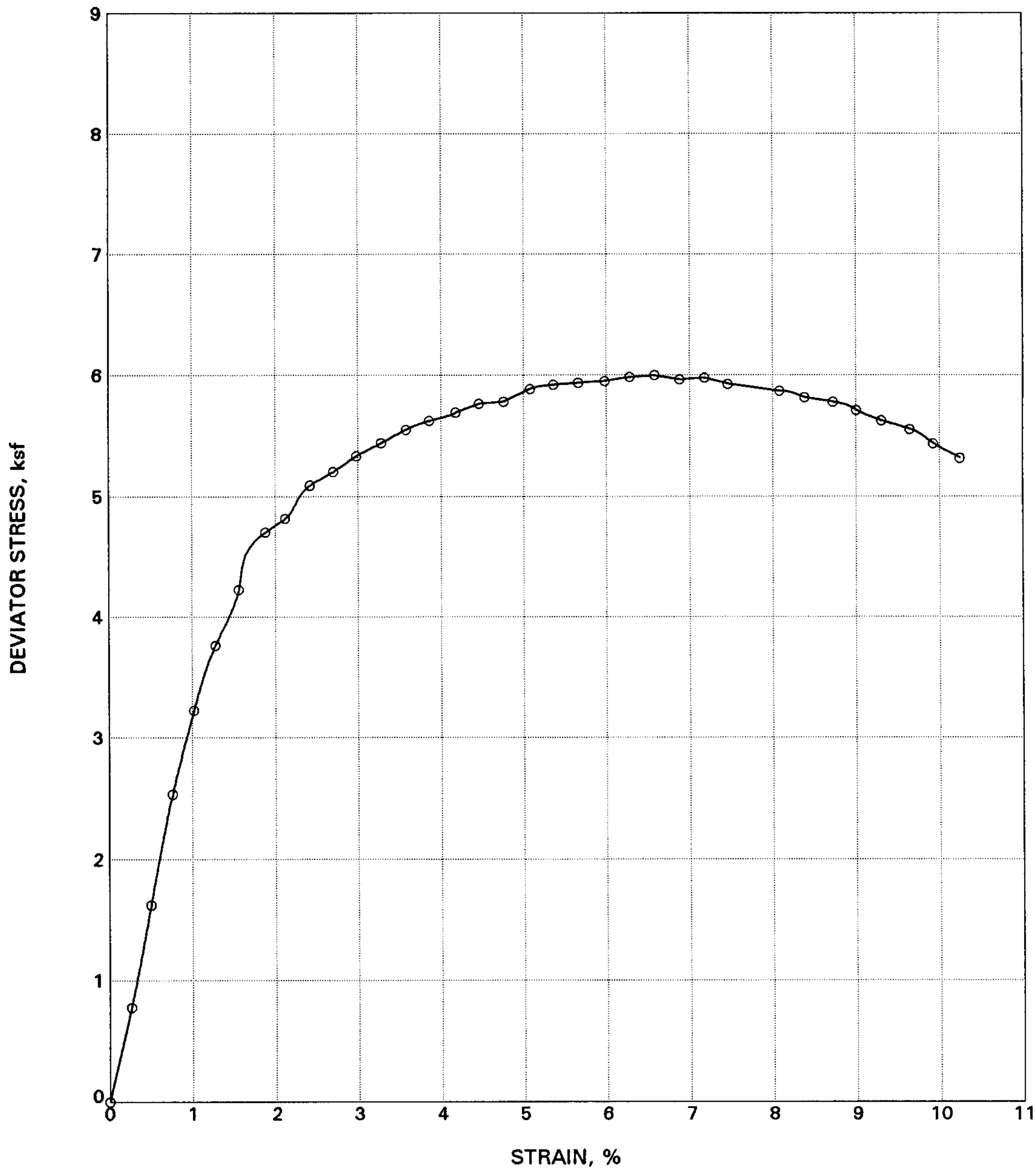
LOCATION	DWP-B2
DEPTH, ft	15.8
MOISTURE CONTENT, %	28
UNIT DRY WEIGHT, pcf	98
MATERIAL DESCRIPTION	Fine SAND with silt (SP-SM)
SAMPLE CONDITION	In Situ

DIRECT SHEAR TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles



EFFECTIVE COHESION, ksf	0.00
EFFECTIVE ANGLE OF INTERNAL FRICTION, deg	30
LOCATION	DWP-B3
DEPTH, ft	4.0
MOISTURE CONTENT, %	28
UNIT DRY WEIGHT, pcf	102
MATERIAL DESCRIPTION	Fine SAND with silt (SP-SM)
SAMPLE CONDITION	In Situ

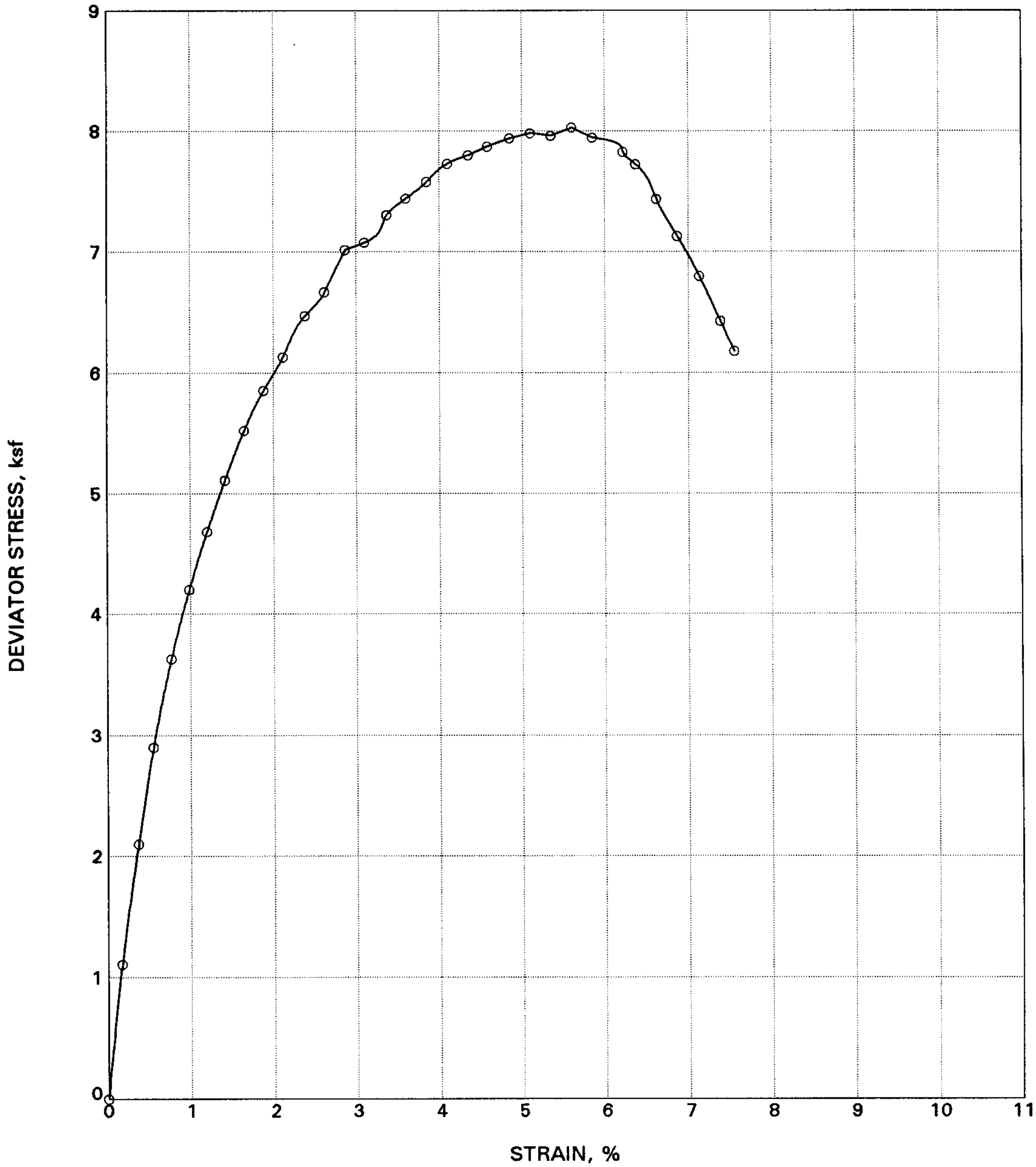
DIRECT SHEAR TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles



PEAK UNDRAINED SHEAR STRENGTH, ksf	3.0
CONFINING STRESS, ksf	0.72
LOCATION	DWP-B5
DEPTH, ft	6.3
MOISTURE CONTENT, %	26
UNIT DRY WEIGHT, pcf	101
MATERIAL DESCRIPTION	Fat CLAY (CH)

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS

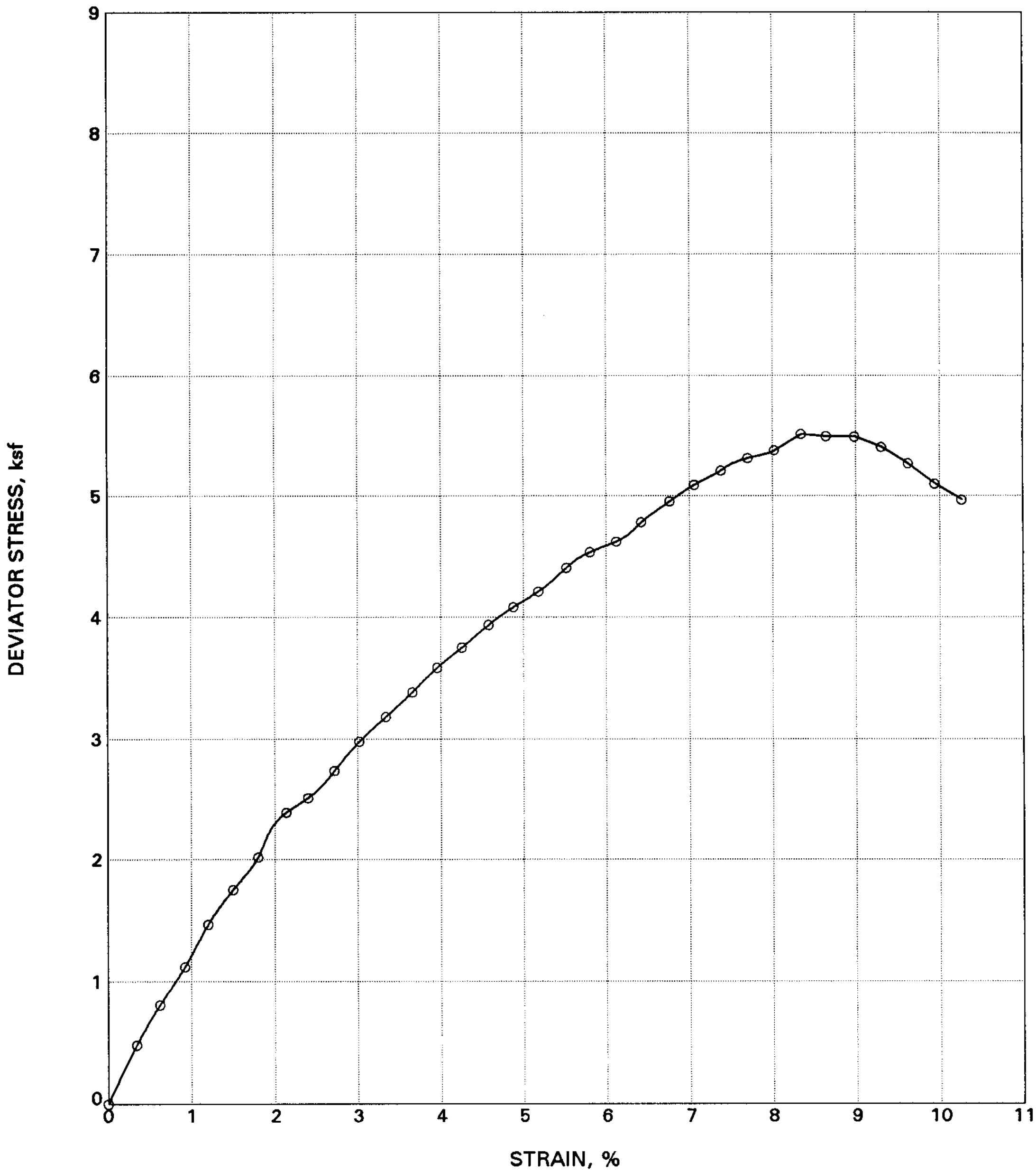
DWP - Reclaimed Water Pipeline
Port of Los Angeles



PEAK UNDRAINED SHEAR STRENGTH, ksf	4.0
CONFINING STRESS, ksf	1.14
LOCATION	DWP-B5
DEPTH, ft	9.1
MOISTURE CONTENT, %	26
UNIT DRY WEIGHT, pcf	104
MATERIAL DESCRIPTION	Fat CLAY (CH)

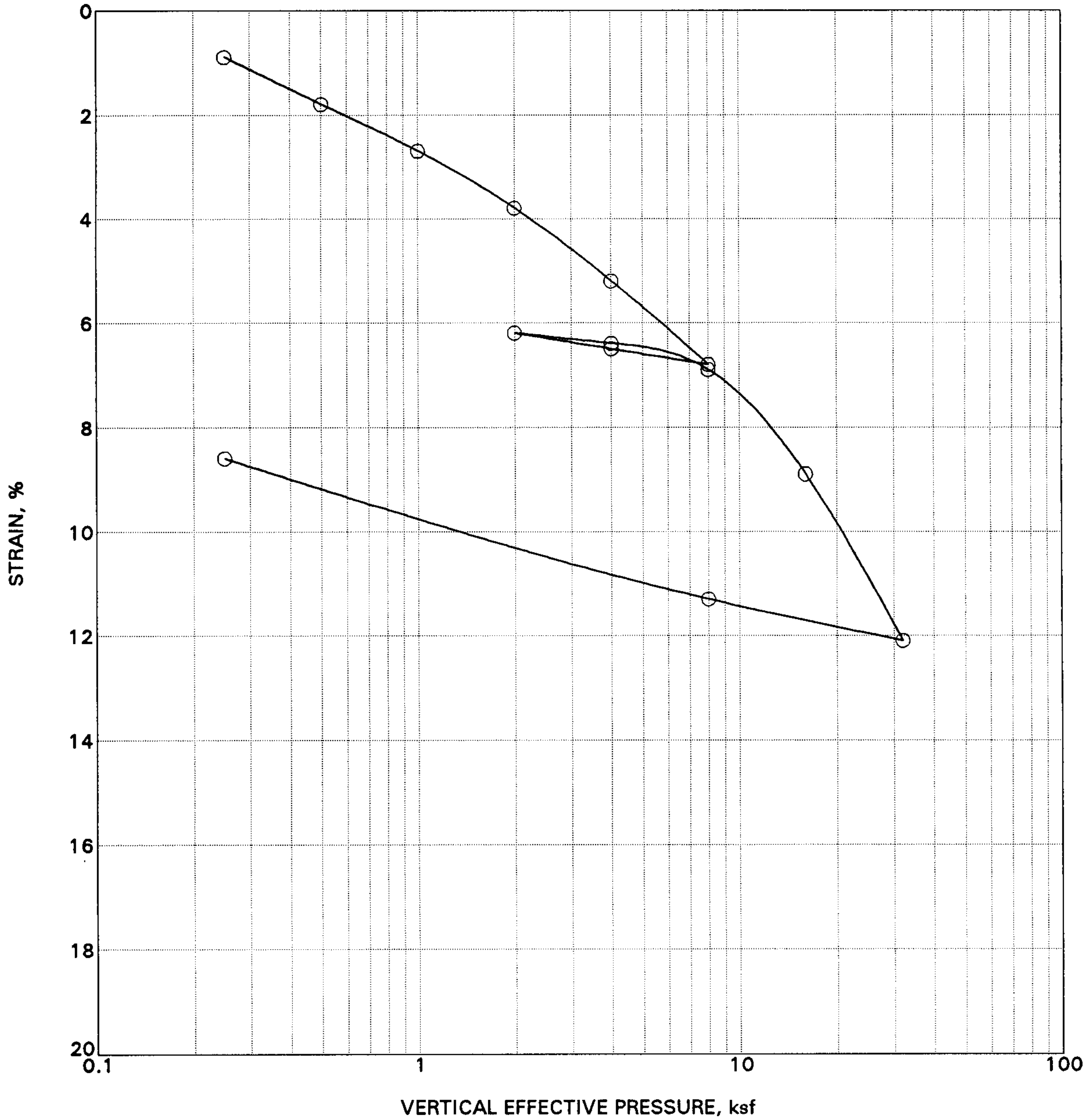
UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS

DWP - Reclaimed Water Pipeline
Port of Los Angeles



PEAK UNDRAINED SHEAR STRENGTH, ksf	2.8
CONFINING STRESS, ksf	2.22
LOCATION	DWP-B6
DEPTH, ft	19.2
MOISTURE CONTENT, %	19
UNIT DRY WEIGHT, pcf	110
MATERIAL DESCRIPTION	Fat CLAY (CH)

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles



LOCATION	DWP-B2
DEPTH, ft	43.0
INITIAL MOISTURE CONTENT, %	31
UNIT DRY WEIGHT, pcf	94
MATERIAL DESCRIPTION	Sandy lean CLAY (CL)
SAMPLE CONDITION	In Situ

CONSOLIDATION TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

CONSOLID(61217)
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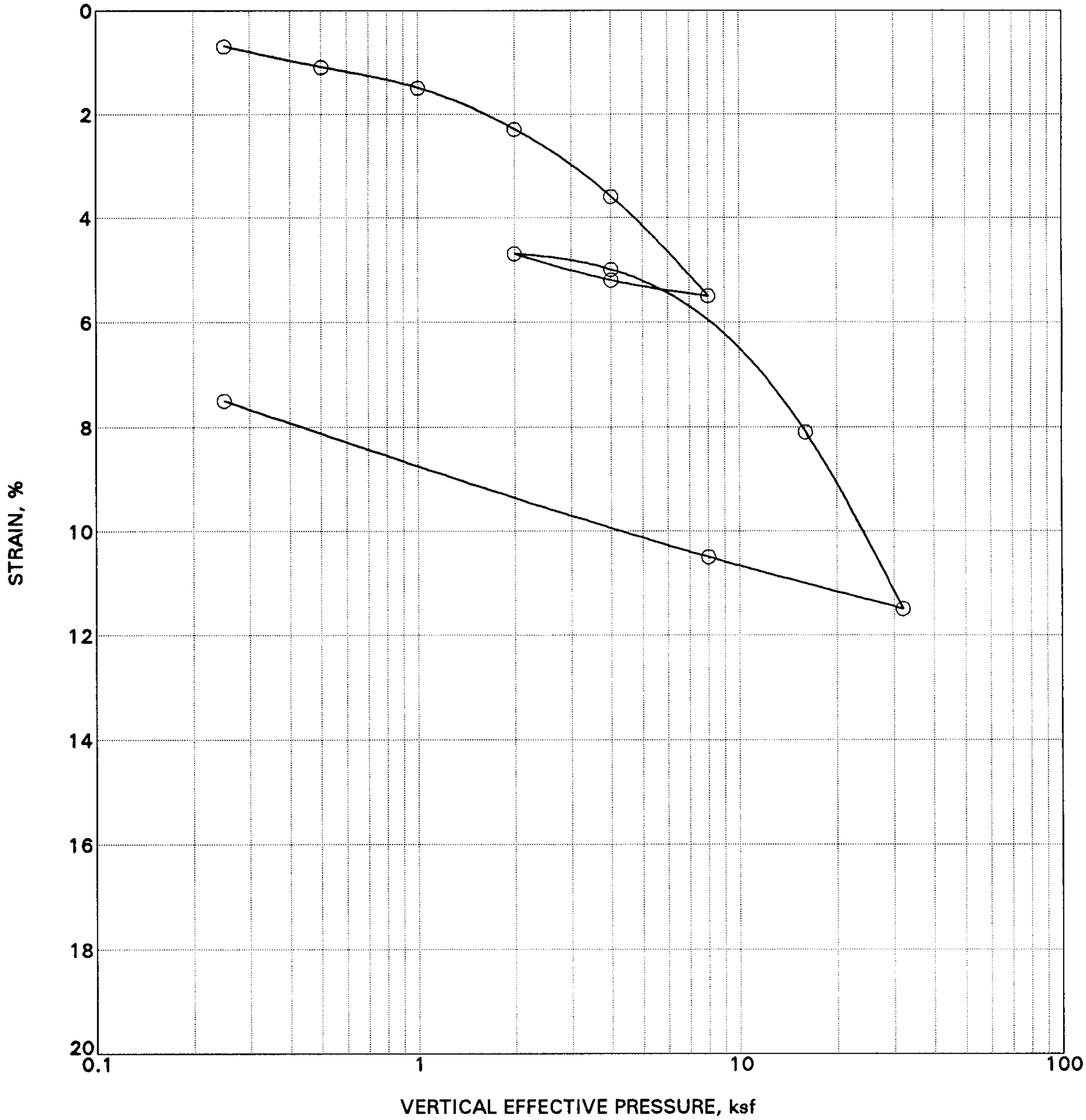


LOCATION	DWP-B6
DEPTH, ft	23.3
INITIAL MOISTURE CONTENT, %	16
UNIT DRY WEIGHT, pcf	110
MATERIAL DESCRIPTION	Fat CLAY (CH)
SAMPLE CONDITION	In Situ

CONSOLIDATION TEST RESULTS
DWP - Reclaimed Water Pipeline
Port of Los Angeles

CONSOLID(61217)
06/19/97\09:47

ConCeCo Engineering, Inc.

RECEIVED
JUL 20 1997
FUGRO WEST, INC.

2160 Winifred Street
Mail: P.O. Box 115
Simi Valley, CA 93062

July 18, 1997

Job No.: 1S97070

Mr. Tom McNeilan
Fugro West, Inc.
5855 Olivas Park Drive
Ventura, CA 93003-7672

Subject: Soil Chemistry Analysis for Pola-DWP
Fugro Job No. 96-42-1217

Dear Mr. McNeilan:

Soil Chemistry Analysis results for project 96-42-1217 are itemized below.

Sample No.	[2] pH	[1] Minimum Resistivity (ohm-cm)	[3] Sulfate (mg/kg)	[3] Chloride (mg/kg)	Description
1	10.75	480	217	229	Gray, Fine Silty Sand Saturated
3	7.80	108	621	4167	Brow, Fine Silty Sand Moist
5	7.64	128	707	4089	Tan Brown, Silty Clay with Sea Shells-Moist
7	7.98	180	646	2413	Brown, Fine Silty Sand Moist

NOTES:

SAMPLES WERE ANALYZED IN ACCORDANCE WITH THE FOLLOWING METHODS.

1. **MINIMUM RESISTIVITY DETERMINED BY SOIL BOX METHOD.**
2. **PH MEASURED BY POTENTIOMETRIC METHOD USING STANDARD ELECTRODES.**
3. **CHLORIDE AND SULFATE WERE ANALYZED IN ACCORDANCE WITH EPA METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTE, NO. 300 (EPA-600/4-79-020).**

Please call me if you have any questions.

Very truly yours,
ConCeCo Engineering, Inc.

Roger J. Carlsen

Roger J. Carlsen, P.E.

RJH:ch

PLATE B-7

APPENDIX C
ADDITIONAL FIELD EXPLORATION DATA

LOCATION: N 4,022,213 E 4,205,445

ELEVATION: -45.0 ft (re: MLLW; based on water depth of 49.5 ft and tide of 4.5 ft)

SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
1	Sandy CLAY (CL) to CLAY with sand (CL): very soft to soft, dark olive gray to black, with mica and few shell fragments - sandy silt to silty sand below 2.5'	42	50	32	11
2	CLAY with sand (CL): olive gray, with mica, shell fragments, and sandy clay zones	34	75	35	16
3			53		
4	Silty, fine to medium SAND (SM) to Sandy SILT (ML): grayish brown, with coarse sand and few gravel		48		

ELEV, ft: -46, -48, -50, -52, -54, -56, -58, -60, -62, -64
DEPTH, ft: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20
CORE RATE, ft/min: 5 10 15 20

PENETRATION DEPTH: 8.0 ft
RECOVERY LENGTH: 7.0 ft
DATE OF EXPLORATION: September 20, 1996

VESSEL: D/W Hood
VIBROCORE TYPE: Geotechnical
REVIEWED BY: GSResnick

LOG OF VIBROCORE NO. VB-34

UGIS ID: FB96VB34

LOCATION: N 4,022,875 E 4,204,948

ELEVATION: -48.6 ft (re: MLLW; based on water depth of 53.5 ft and tide of 4.9 ft)

SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
1	CLAY with sand (CL): very soft to soft, dark olive gray, with mica and shell fragments	45	82	42	18
2	SILT/CLAY (ML/CL): firm, olive gray, with mica, shells and shell fragments - sandy silt, abundant shell fragments, 1' to 1.5'	42	91	46	19
3		39	97	43	17
4		36			
5					
6	Silty fine SAND (SM): olive gray, with mica and shell fragments - few silt seams 12.5' to 13.5'		26		

ELEV, ft: -50, -52, -54, -56, -58, -60, -62, -64, -66, -68
DEPTH, ft: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20
CORE RATE, ft/min: 5 10 15 20

PENETRATION DEPTH: 18.0 ft
RECOVERY LENGTH: 15.0 ft
DATE OF EXPLORATION: September 20, 1996

VESSEL: D/W Hood
VIBROCORE TYPE: Geotechnical
REVIEWED BY: GSResnick

LOG OF VIBROCORE NO. VB-35

UGIS ID: FB96VB35

LOGS OF VIBROCORES
Inner Harbor Deepening

61212VIB (61212)
06/18/97 02:09PM

FUGRO

LOG OF VIBROCORE NO. CG4-1

LOCATION: N 4,021,608 E 4,206,360

ELEVATION: -47.2 ft (re: MLLW; based on water depth of -51.4 ft and tide of 4.2 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
-48		1	CLAY with sand (CL): very soft, dark olive gray to black, with mica and few shell fragments	32			
-50	2	2	Silty fine SAND (SM) to SAND with silt (SP-SM): yellowish red, with mica - dark olive silt layer with black nodules at 2.75' to 3.25' - few silt nodules at 4.5' to 7'	20	14		
-52	4						
-54	6	3					
-56	8		Fine SAND (SP) to SAND with silt (SP-SM): light yellowish red, with mica, limited iron staining				
-58	10						
-60	12	4			2		
-62	14		Fine to medium SAND with silt (SP-SM): light gray, with mica - abundant shell fragments at 14.75' to 16.5'				
-64	16						
-66	18	5					
	20						

CORE RATE, ft/min (5 10 15 20)

PENETRATION DEPTH: 19.8 ft
RECOVERY LENGTH: 19.8 ft
DATE OF EXPLORATION: April 19, 1997

VESSEL: D/W Hood
VIBROCORE TYPE: Environmental
REVIEWED BY: FJArnold

UGIS ID: FD97V028

LOG OF VIBROCORE NO. CG4-5

LOCATION: N 4,022,660 E 4,205,811

ELEVATION: -42.5 ft (re: MLLW; based on water depth of -43.3 ft and tide of 0.8 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
-44			Clayey fine SAND (SC) to Sandy CLAY (CL): black to olive gray, with mica				
-46	2	1		33	42	30	11
-48	4						
-50	6	2	Fine SAND with silt (SP-SM): olive gray, with mica and limited shell fragments - clay seam at 8.5' - abundant shells below 9.5'		5		
-52	8						
-54	10	3	Silty fine SAND (SM) to SAND with silt (SP-SM): olive gray to light gray, faint iron staining, with silt and sandy silt layers and seams		52		
-56	12						
-58	14	4	- stiff clay layer at 14.5' to 15' - stiff clay layer at 15.75' to 16.75'				
-60	16	5					
-62	18		- with reddish brown bands below 19'				
	20						

CORE RATE, ft/min (5 10 15 20)

PENETRATION DEPTH: 20.0 ft
RECOVERY LENGTH: 20.0 ft
DATE OF EXPLORATION: April 19, 1997

VESSEL: D/W Hood
VIBROCORE TYPE: Environmental
REVIEWED BY: FJArnold

UGIS ID: FD97V032

LOGS OF VIBROCORES
POLA Channel Deepening

LOCATION: N 4,021,470 E 4,206,142

ELEVATION: -48.7 ft (re: MLLW; based on water depth of -48.8 ft and tide of 0.1 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
-50		1	CLAY with sand (CL): firm to stiff, light brown - increasing sand content at 1.5'	23			
-52	2	2	Fat CLAY (CH): very stiff to hard, light to medium brown	30	94	79	54

CORE RATE, ft/min: 5 10 15 20

PENETRATION DEPTH: 4.5 ft
RECOVERY LENGTH: 3.7 ft
DATE OF EXPLORATION: April 5, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Environmental
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. FG1-7

UGIS ID: FD97V044

LOCATION: N 4,022,616 E 4,205,445

ELEVATION: -50.2 ft (re: MLLW; based on water depth of -55.3 ft and tide of 5.1 ft)

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
		1	Clayey fine SAND (SC) to Sandy CLAY (CL): olive gray to gray, with mica and shell fragments	22	13		
-52	2	2	Silty fine SAND (SM) to Sandy SILT (ML): light brown to yellowish brown, with gray streaks		31		

CORE RATE, ft/min: 5 10 15 20

PENETRATION DEPTH: 3.0 ft
RECOVERY LENGTH: 2.5 ft
DATE OF EXPLORATION: April 5, 1997

VESSEL: R/W Hood
VIBROCORE TYPE: Environmental
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. FG1-10

UGIS ID: FD97V047

LOGS OF VIBROCORES
POLA Channel Deepening

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
			LOCATION: N 4,021,553 E 4,205,820 ELEVATION: -50.5 ft (re: MLLW; based on water depth of -51.5 ft and tide of 1.0 ft)				
-52		1	Sandy CLAY (CL): very soft to soft, olive gray to gray, with mica, few shell fragments, concretions, and few gravel to 1/2"	27	57	41	24
-54	2	2		21			
-56	4	3	Silty fine SAND (SM) to fine SAND (SP): light brown, with mica, few coarse sand particles and gravel to 1/2"		14		
-58	6	4					
-60	8		- increasing gravel content, gravel to 1", at 9.25' to 10.25'				
-62	10	5	- becomes orangish light brown at 11.5'				
-64	12	6			2		
-66	14	7	- slight increase in gravel content, gravel to 3/4", at 13.5'				
-68	16	8	- becomes fine to medium grained, gravel to 1.5", at 16'				
-70	18						
	20						

CORE RATE, ft/min (5 10 15 20)

PENETRATION DEPTH: 18.0 ft
RECOVERY LENGTH: 17.5 ft
DATE OF EXPLORATION: April 22, 1997

VESSEL: D/W Hood
VIBROCORE TYPE: Geotechnical
REVIEWED BY: SGSukiasian

LOG OF VIBROCORE NO. GT-4

UGIS ID: FD97V086

ELEV, ft	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
			LOCATION: N 4,022,989 E 4,205,215 ELEVATION: -51.9 ft (re: MLLW; based on water depth of -53.1 ft and tide of 1.2 ft)				
		1	CLAY with sand (CL): soft, olive gray, with shells				
-54			SILT/CLAY (ML/CL): firm, olive gray, with mica and some shell fragments	37			
	2	2		38	94	42	15
-56	4		- thin shell layer at 3.75'				
-58	6	3	Sandy SILT (ML) to Silty fine SAND (SM): olive gray, with mica, shells and shell fragments				
-60	8	4			27		
-62	10						
-64	12	5	- firm to stiff, olive gray clay, at 12.25' to 12.75'				
-66	14						
-68	16	6	Silty fine SAND (SM): olive gray, with mica, shell fragments, and faint iron staining		37		
-70	18						
-72	20						

CORE RATE, ft/min (5 10 15 20)

PENETRATION DEPTH: 19.0 ft
RECOVERY LENGTH: 19.0 ft
DATE OF EXPLORATION: April 22, 1997

VESSEL: D/W Hood
VIBROCORE TYPE: Geotechnical
REVIEWED BY: FJArnold

LOG OF VIBROCORE NO. GT-5

UGIS ID: FD97V087

LOGS OF VIBROCORES
POLA Channel Deepening

FUGRO

LOG OF VIBROCORE NO. GT-11

LOCATION: N 4,022,499 E 4,205,924

ELEVATION: -44.2 ft (re: MLLW; based on water depth of -45.8 ft and tide of 1.6 ft)

Sample Number	Material Description	Water Content, %	% Passing #200 Sieve	Liquid Limit, %	Plasticity Index, %
1	Fine to medium SAND with silt (SP-SM): dark olive gray, with mica, abundant shell fragments and some fine gravel				
2	Silty fine SAND (SM): dark olive gray to black, with mica, some shell fragments, and dark gray silt pockets		34		
3	Fine SAND with silt (SP-SM): dark olive gray, with mica and shell fragments - abundant shells, shell fragments, and some fine gravel, below 6'				
4	Fine SAND with silt (SP-SM) to SAND (SP): light gray to yellowish brown, with mica and shell fragments, faint iron staining - abundant shells at 10' to 11' - decreasing shells and shell fragments below 11.5'		5		
5			3		
6	- becomes reddish brown (extreme iron staining?) below 16'				

Elevation scale (ft): -46, -48, -50, -52, -54, -56, -58, -60, -62, -64; Depth scale (ft): 2, 4, 6, 8, 10, 12, 14, 16, 18, 20. Core rate, ft/min: 5, 10, 15, 20.

PENETRATION DEPTH: 19.5 ft
RECOVERY LENGTH: 19.5 ft
DATE OF EXPLORATION: April 22, 1997

VESSEL: D/W Hood
VIBROCORE TYPE: Geotechnical
REVIEWED BY: FJArnold

UGIS ID: FD97V093

LOG OF VIBROCORE NO. GT-12

LOCATION: N 4,021,324 E 4,206,446

ELEVATION: -45.6 ft (re: MLLW; based on water depth of -49.5 ft and tide of 3.9 ft)

Sample Number	Material Description	Water Content, %	% Passing #200 Sieve	Liquid Limit, %	Plasticity Index, %
1	CLAY with sand (CL) to Sandy CLAY (CL): dark gray, with mica, some organics, and petroleum odor	38			
2	Silty fine SAND (SM): gray to dark gray, with mica and few shell fragments		14		
3					
4	CLAY with sand (CL): dark gray to black, with mica and few shell fragments	35			
5	Silty fine SAND (SM): light brown and dark gray, with mica, wood fragments, and shell fragments - becomes light brown, increasing silt content and increasing shell fragments, at 10'		31		
6	- with light gray clay seams at 11.5' to 12' - increasing shell fragments at 12.5' to 13'				
7	Fine SAND (SP): light brown, with mica and shell fragments		2		
8	- shell hash at 15.5'				

Elevation scale (ft): -48, -50, -52, -54, -56, -58, -60, -62, -64, -66; Depth scale (ft): 2, 4, 6, 8, 10, 12, 14, 16, 18, 20. Core rate, ft/min: 5, 10, 15, 20.

PENETRATION DEPTH: 19.5 ft
RECOVERY LENGTH: 19.5 ft
DATE OF EXPLORATION: April 22, 1997

VESSEL: D/W Hood
VIBROCORE TYPE: Geotechnical
REVIEWED BY: SGSukiasian

UGIS ID: FD97V094

LOGS OF VIBROCORES
POLA Channel Deepening

61212VIB (61215)
06/18/97 12:39PM

ELEV, ft	DEPTH, ft	MATERIAL SYMBOL	SAMPLE	SAMPLE NUMBER	LOCATION: N 4,022,860 E 4,205,944 ELEVATION: -43.2 ft (re: MLLW; based on water depth of -45.1 ft and tide of 1.9 ft) MATERIAL DESCRIPTION	CORE RATE, ft/min (5 10 15 20)	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %
-44				1	Sandy CLAY (CL) to CLAY with sand (CL): very soft, black, with organics, some mica and petroleum odor		50	58	38	15
-46	2									
-48	4			2	Silty fine SAND (SM): black, with mica, some shell fragments, and few organic pieces			34		
-50	6				- pockets of gray sand with shells below 6'					
-52	8			3	Fine SAND with silt (SP-SM): olive gray, with mica and abundant shell fragments					
-54	10									
-56	12									
-58	14									
-60	16									
-62	18									
	20									

PENETRATION DEPTH: 9.0 ft
RECOVERY LENGTH: 8.0 ft
DATE OF EXPLORATION: April 25, 1997

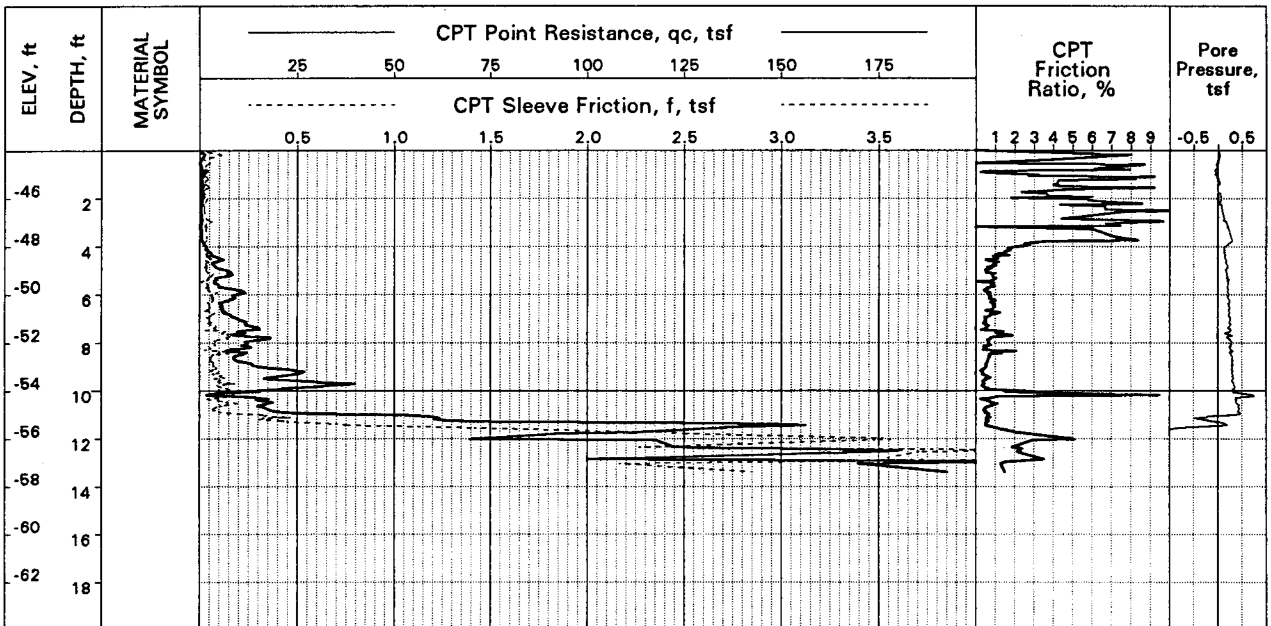
VESSEL: D/W Hood
VIBROCORE TYPE: Harbor Bottom Sed.
REVIEWED BY: FJArnold

LOG OF VIBROCORE NO. GT-24

UGIS ID: FD97V106

LOGS OF VIBROCORES
POLA Channel Deepening

61212VIB (61215)
06/18/97 12:40PM



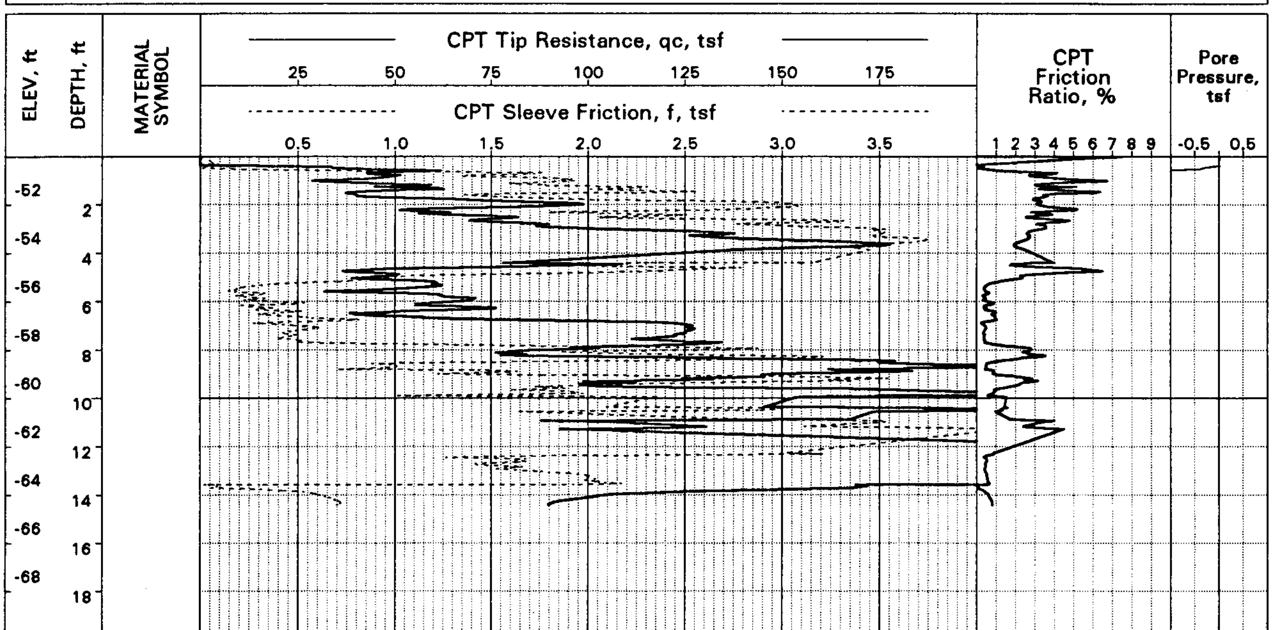
LOCATION: N 4,021,460 E 4,206,555
ELEVATION: -44.1 ft (re: MLLW; based on water depth of 49 ft and tide of 4.9 ft)

COMPLETION DEPTH: 13.8 ft
DATE OF EXPLORATION: August 5, 1996

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CB-20

UGIS ID: FB96CB20



LOCATION: N 4,021,758 E 4,206,193
ELEVATION: -50.4 ft (re: MLLW; based on water depth of 55 ft and tide of 4.6 ft)

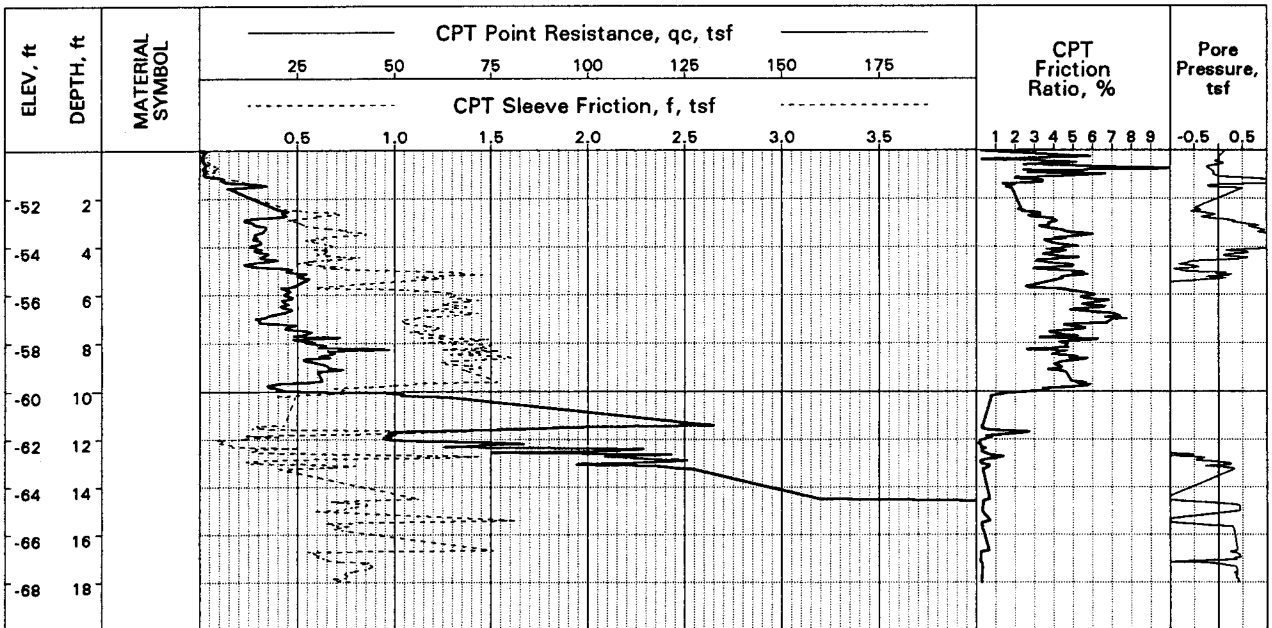
COMPLETION DEPTH: 14.4 ft
DATE OF EXPLORATION: August 5, 1996

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CB-21

UGIS ID: FB96CB21

LOGS OF CPTs



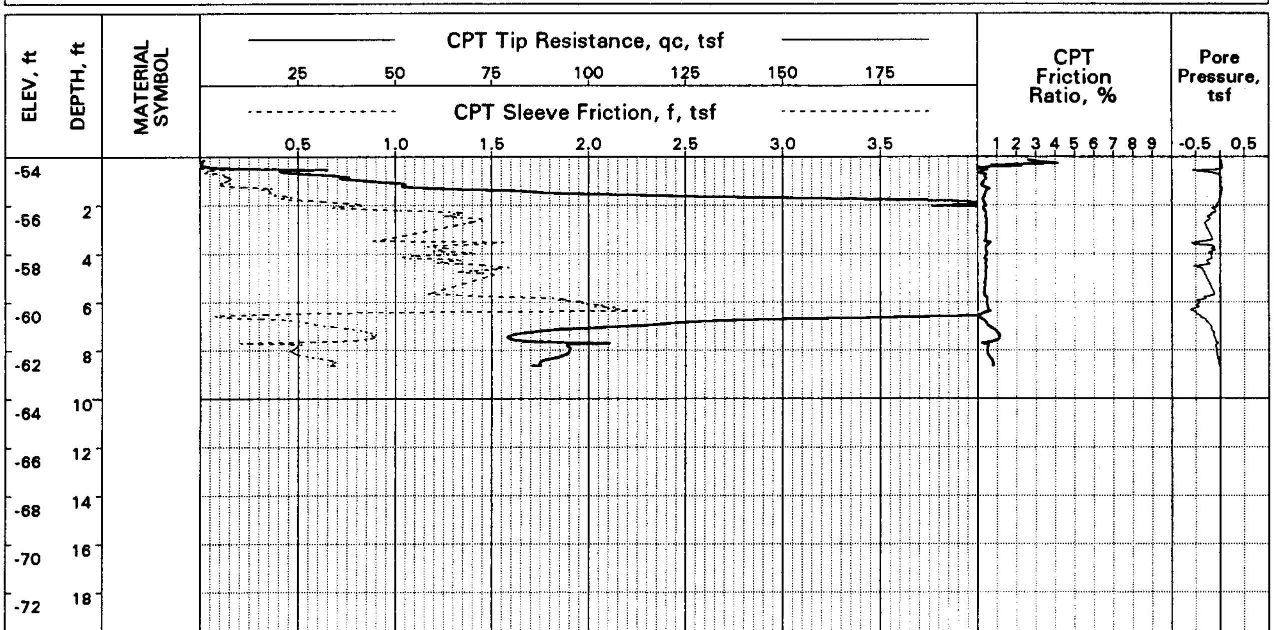
LOCATION: N 4,021,931 E 4,205,637
ELEVATION: -49.5 ft (re: MLLW; based on water depth of 54 ft and tide of 4.5 ft)

COMPLETION DEPTH: 18.0 ft
DATE OF EXPLORATION: August 5, 1996

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CB-22

UGIS ID: FB96CB22



LOCATION: N 4,022,271 E 4,206,082
ELEVATION: -53.2 ft (re: MLLW; based on water depth of 58 ft and tide of 4.8 ft)

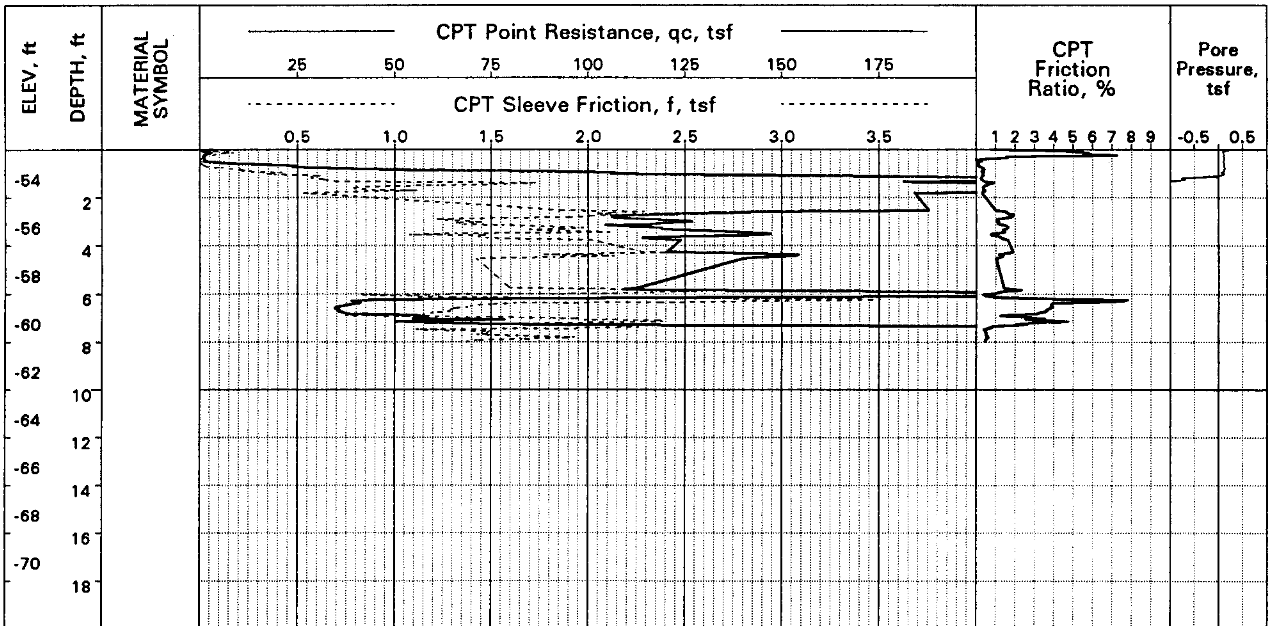
COMPLETION DEPTH: 8.5 ft
DATE OF EXPLORATION: August 6, 1996

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CB-25

UGIS ID: FB96CB25

LOGS OF CPTs



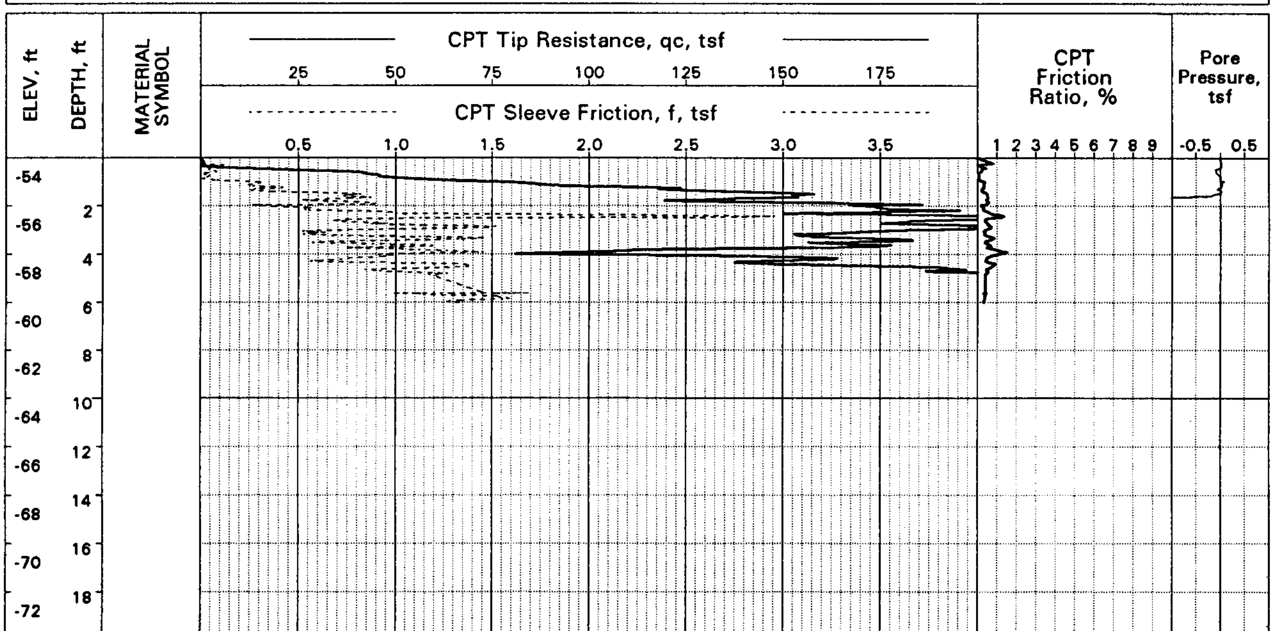
LOCATION: N 4,022,710 E 4,205,430
ELEVATION: -52.5 ft (re: MLLW; based on water depth of 55 ft and tide of 2.5 ft)

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 7.9 ft
DATE OF EXPLORATION: August 6, 1996

LOG OF CPT NO. CB-26

UGIS ID: FB96CB26



LOCATION: N 4,022,724 E 4,205,450
ELEVATION: -53.0 ft (re: MLLW; based on water depth of 56 ft and tide of 3.0 ft)

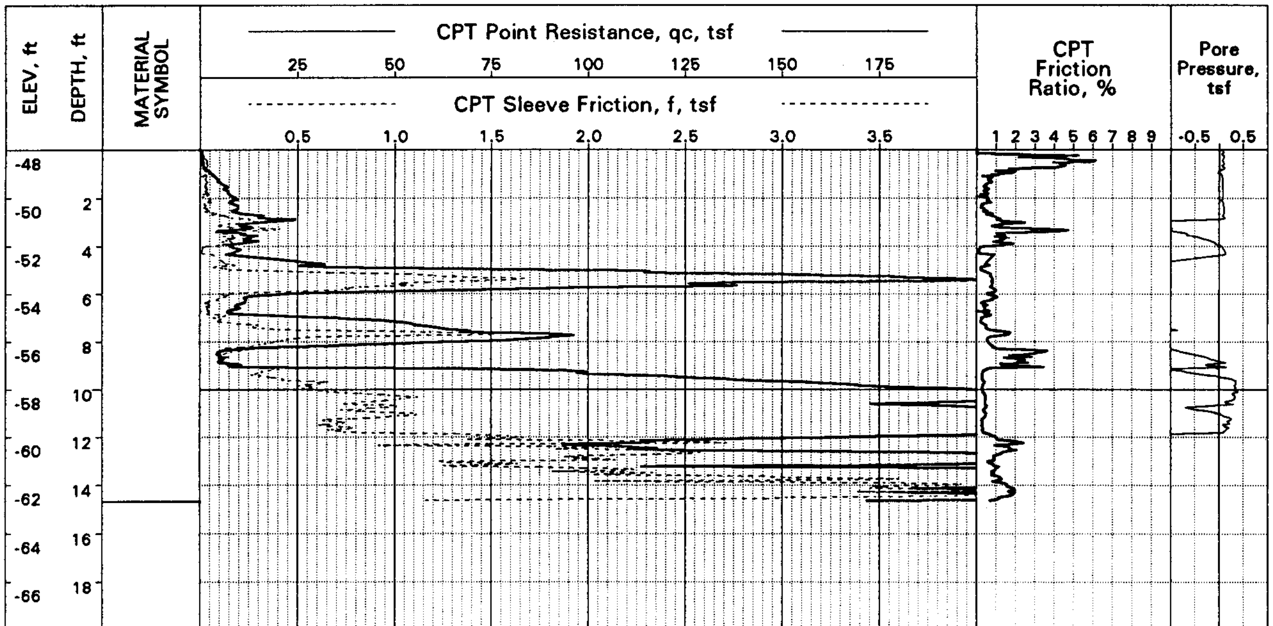
VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 5.9 ft
DATE OF EXPLORATION: August 8, 1996

LOG OF CPT NO. CB-49

UGIS ID: FB96CB49

LOGS OF CPTs



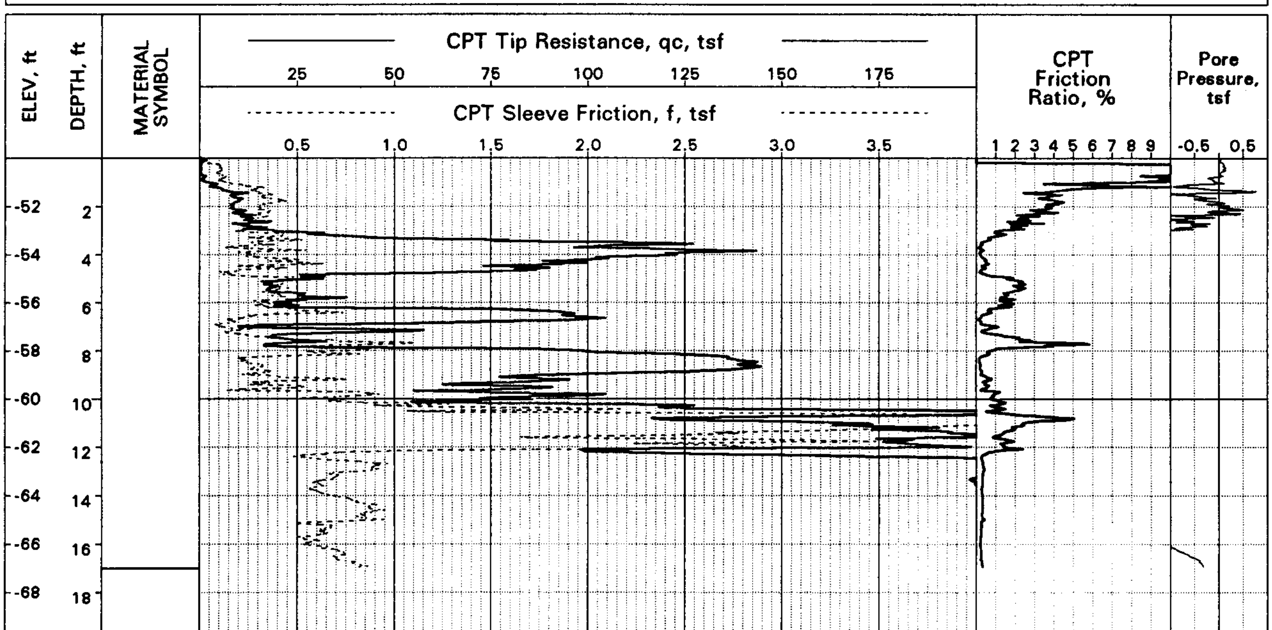
LOCATION: N 4,022,368 E 4,205,392
ELEVATION: -47.2 ft (re: MLLW; based on water depth of 48.0 ft and tide of 0.8 ft)

COMPLETION DEPTH: 14.7 ft
DATE OF EXPLORATION: April 21, 1997

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CPT-06

UGIS ID: FD97C006



LOCATION: N 4,022,991 E 4,205,184
ELEVATION: -49.8 ft (re: MLLW; based on water depth of 52.0 ft and tide of 2.2 ft)

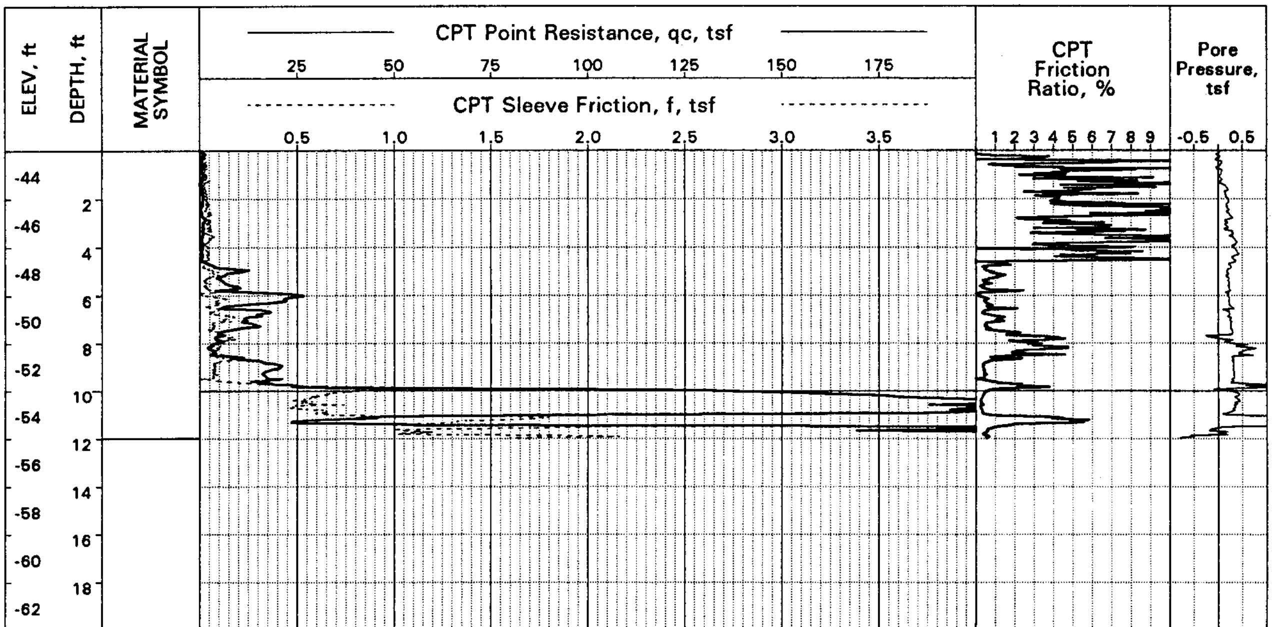
COMPLETION DEPTH: 17.0 ft
DATE OF EXPLORATION: April 24, 1997

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CPT-07

UGIS ID: FD97C007

LOGS OF CPTs
POLA Channel Deepening
Port of Los Angeles



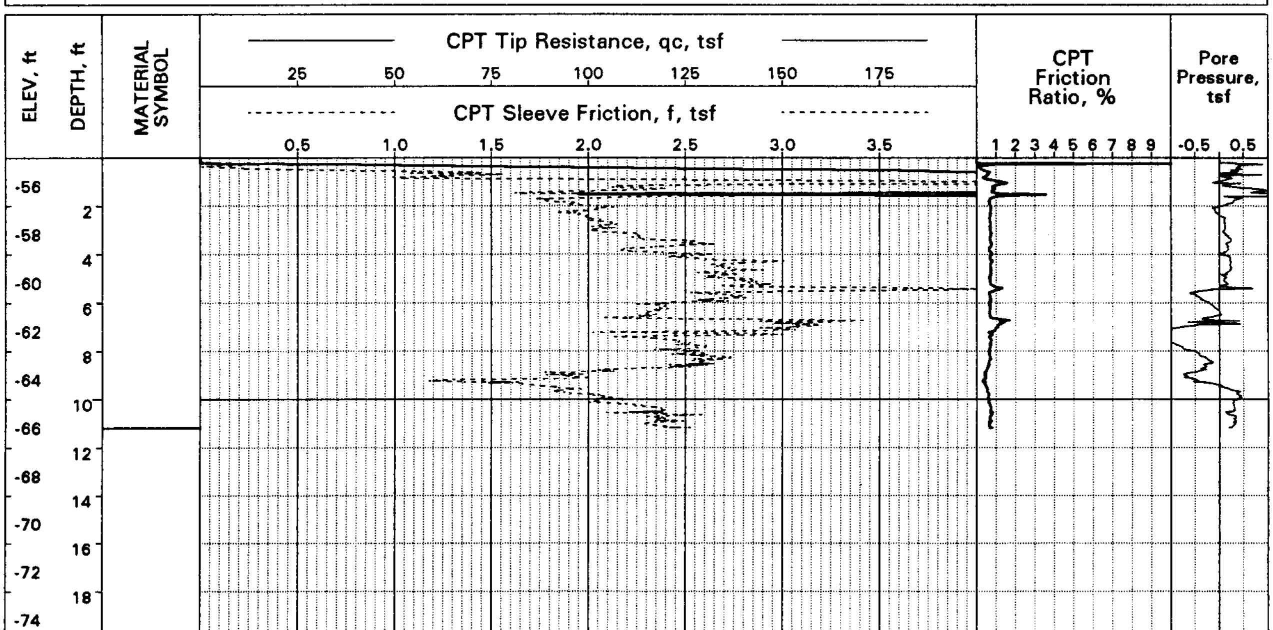
LOCATION: N 4,022,821 E 4,205,694
ELEVATION: -42.7 ft (re: MLLW; based on water depth of 43.5 ft and tide of 0.8 ft)

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 12.0 ft
DATE OF EXPLORATION: April 21, 1997

LOG OF CPT NO. CPT-22

UGIS ID: FD97C022



LOCATION: N 4,022,130 E 4,206,160
ELEVATION: -54.6 ft (re: MLLW; based on water depth of 56.0 ft and tide of 1.4 ft)

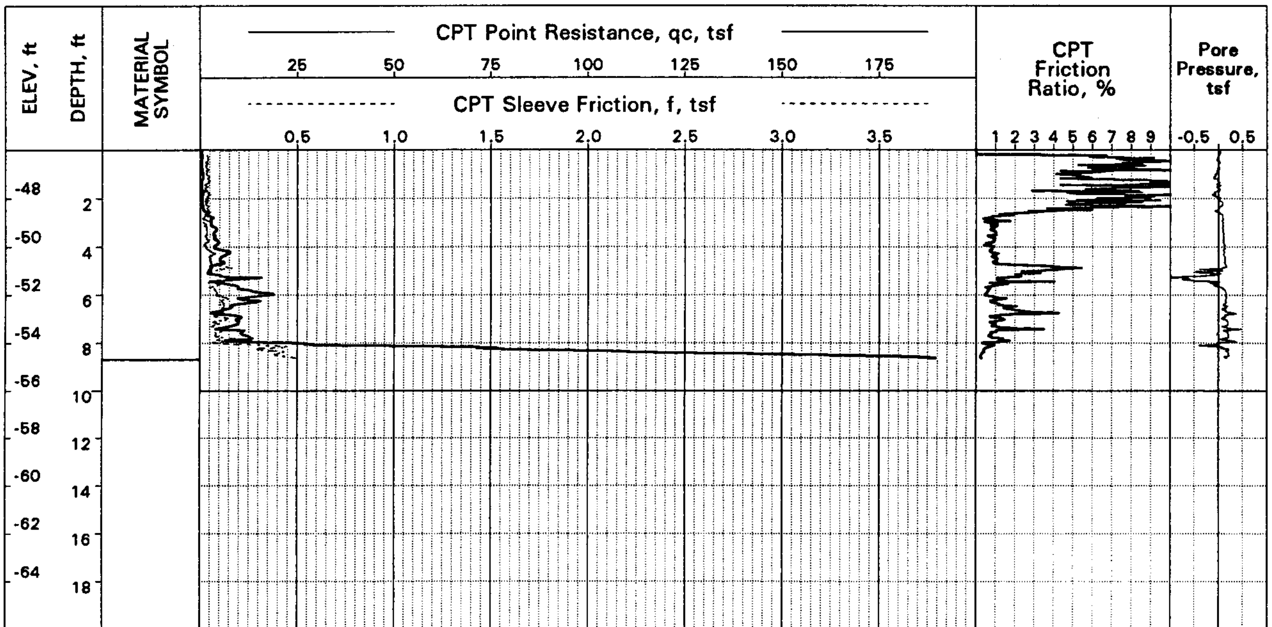
VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 11.2 ft
DATE OF EXPLORATION: April 25, 1997

LOG OF CPT NO. CPT-24

UGIS ID: FD97C024

LOGS OF CPTs
POLA Channel Deepening
Port of Los Angeles



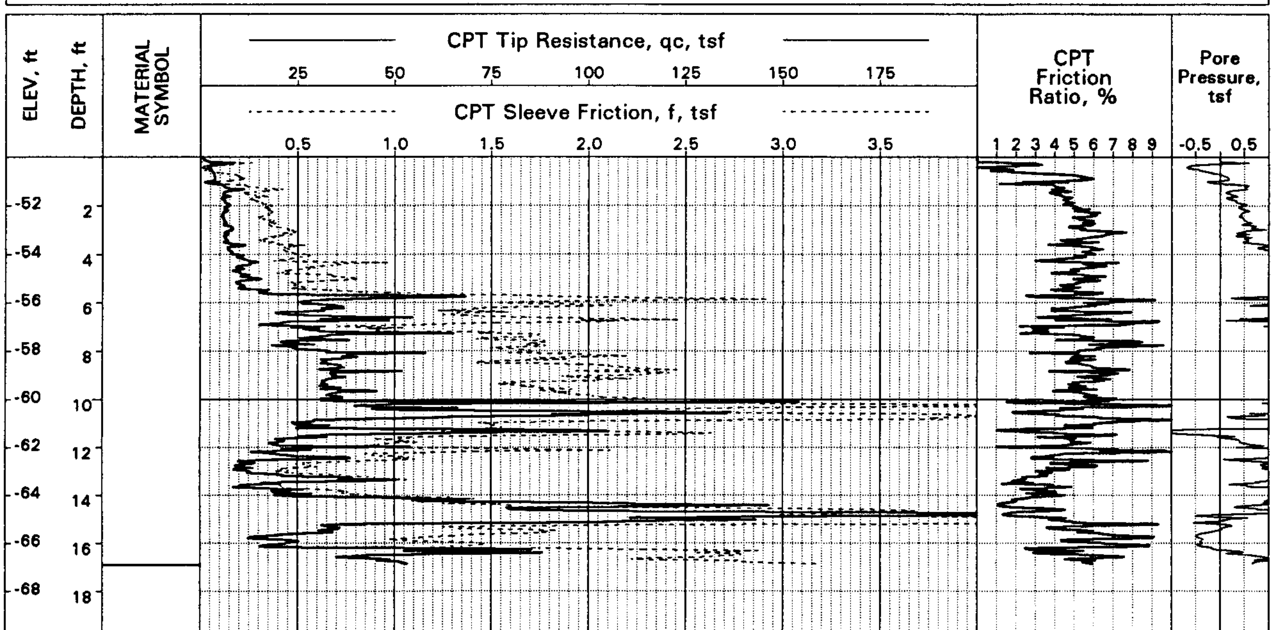
LOCATION: N 4,021,308 E 4,206,426
ELEVATION: -46.2 ft (re: MLLW; based on water depth of 48.0 ft and tide of 1.8 ft)

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 8.7 ft
DATE OF EXPLORATION: April 24, 1997

LOG OF CPT NO. CPT-26

UGIS ID: FD97C026



LOCATION: N 4,021,542 E 4,206,049
ELEVATION: -49.9 ft (re: MLLW; based on water depth of 51.8 ft and tide of 1.9 ft)

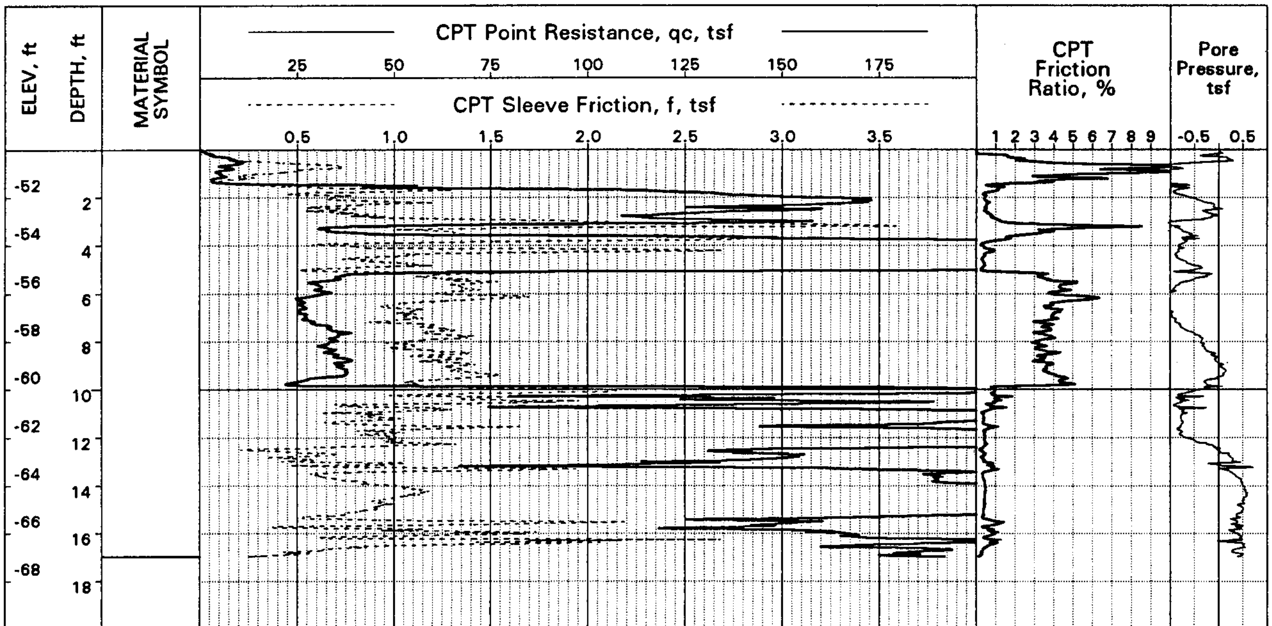
VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 16.9 ft
DATE OF EXPLORATION: April 25, 1997

LOG OF CPT NO. CPT-36

UGIS ID: FD97C036

LOGS OF CPTs
POLA Channel Deepening
Port of Los Angeles



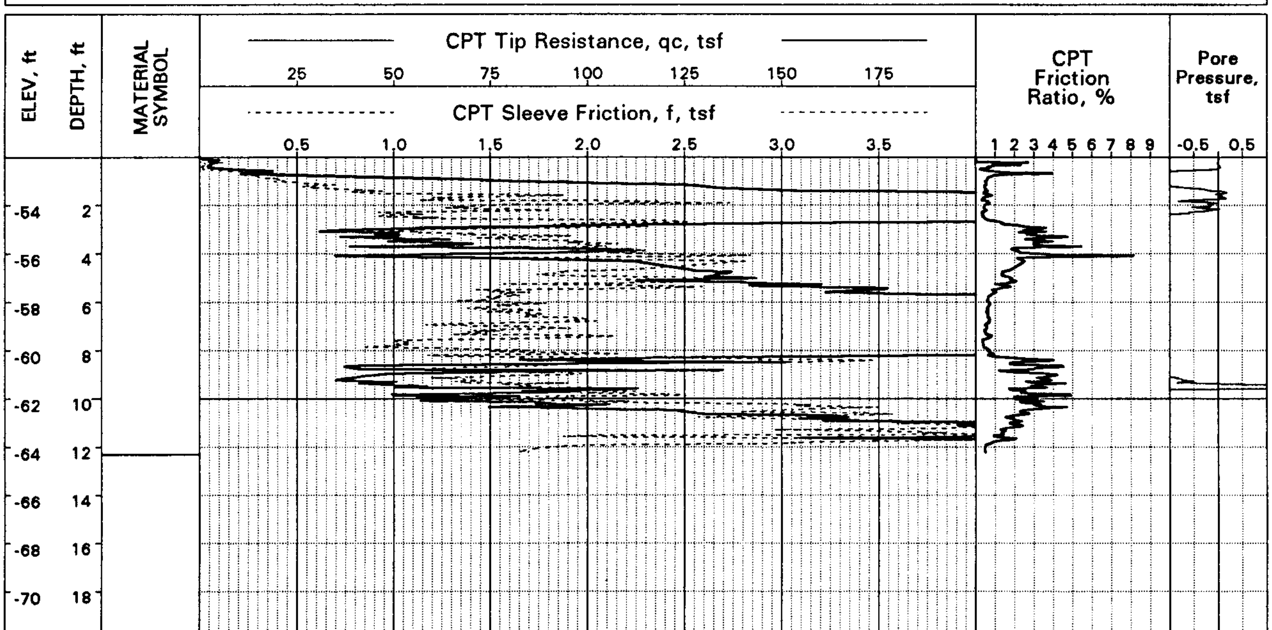
LOCATION: N 4,021,860 E 4,205,899
ELEVATION: -50.3 ft (re: MLLW; based on water depth of 52.0 ft and tide of 1.7 ft)

COMPLETION DEPTH: 17.0 ft
DATE OF EXPLORATION: April 25, 1997

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CPT-37

UGIS ID: FD97C037



LOCATION: N 4,022,281 E 4,205,705
ELEVATION: -51.5 ft (re: MLLW; based on water depth of 52.4 ft and tide of 0.9 ft)

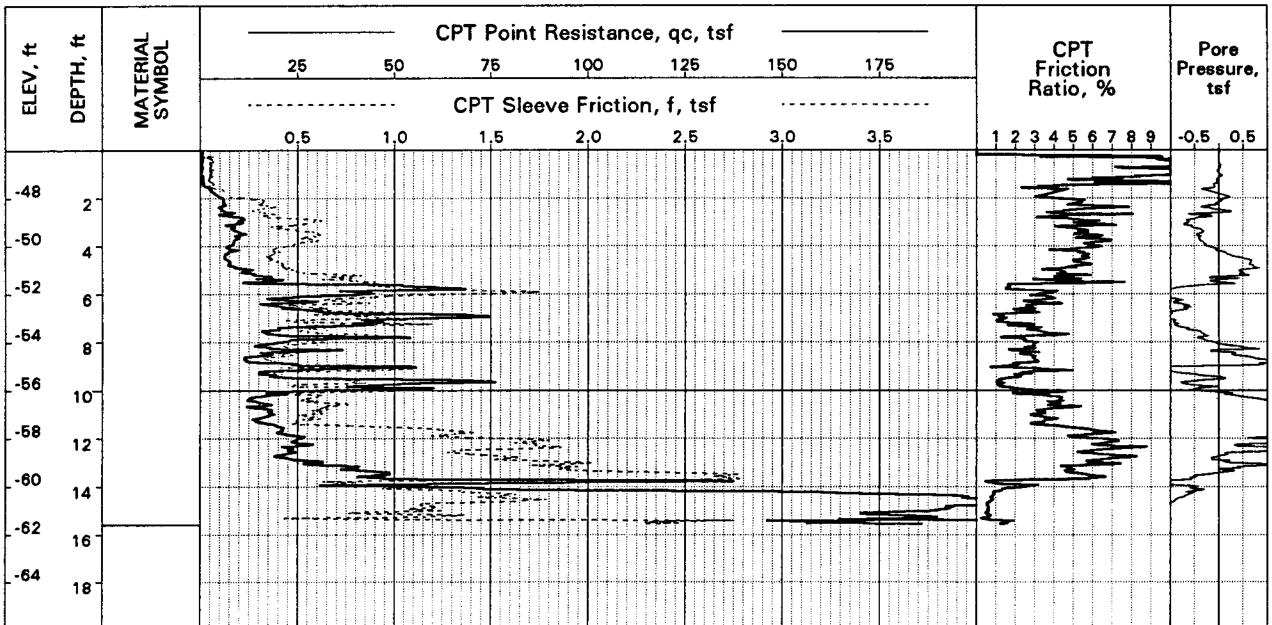
COMPLETION DEPTH: 12.3 ft
DATE OF EXPLORATION: April 21, 1997

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CPT-38

UGIS ID: FD97C038

LOGS OF CPTs
POLA Channel Deepening
Port of Los Angeles



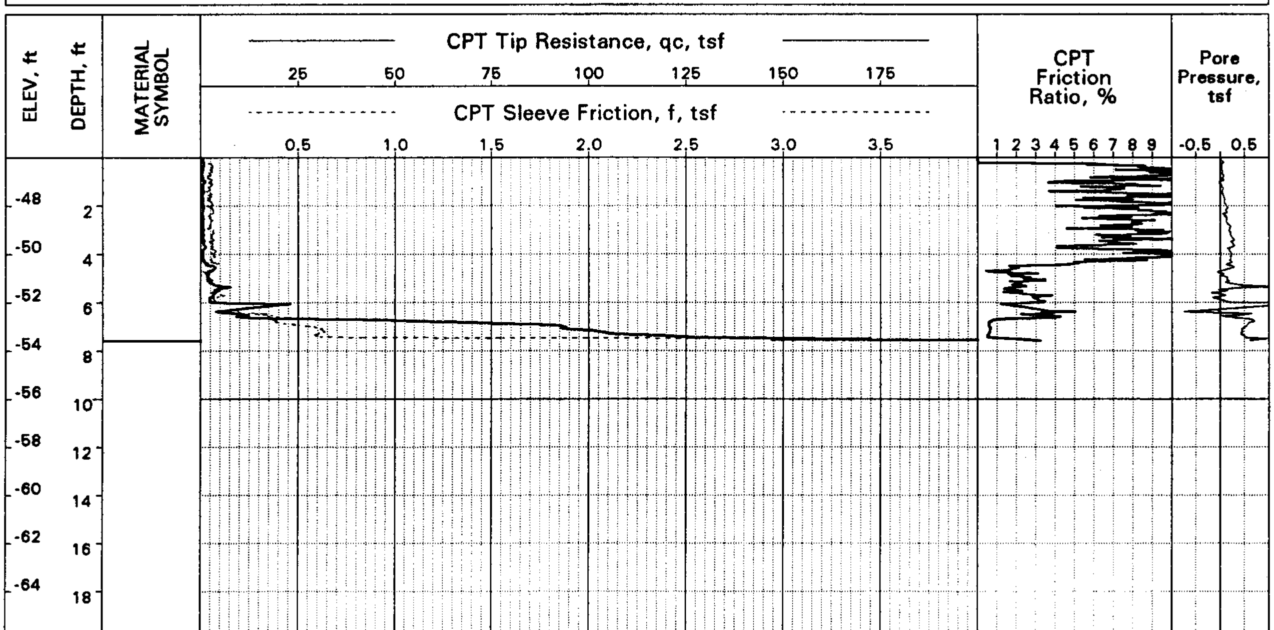
LOCATION: N 4,020,960 E 4,206,152
ELEVATION: -46.1 ft (re: MLLW; based on water depth of 48.1 ft and tide of 2.0 ft)

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 15.6 ft
DATE OF EXPLORATION: April 25, 1997

LOG OF CPT NO. CPT-75

UGIS ID: FD97C075



LOCATION: N 4,021,147 E 4,206,325
ELEVATION: -46.1 ft (re: MLLW; based on water depth of 48.0 ft and tide of 1.9 ft)

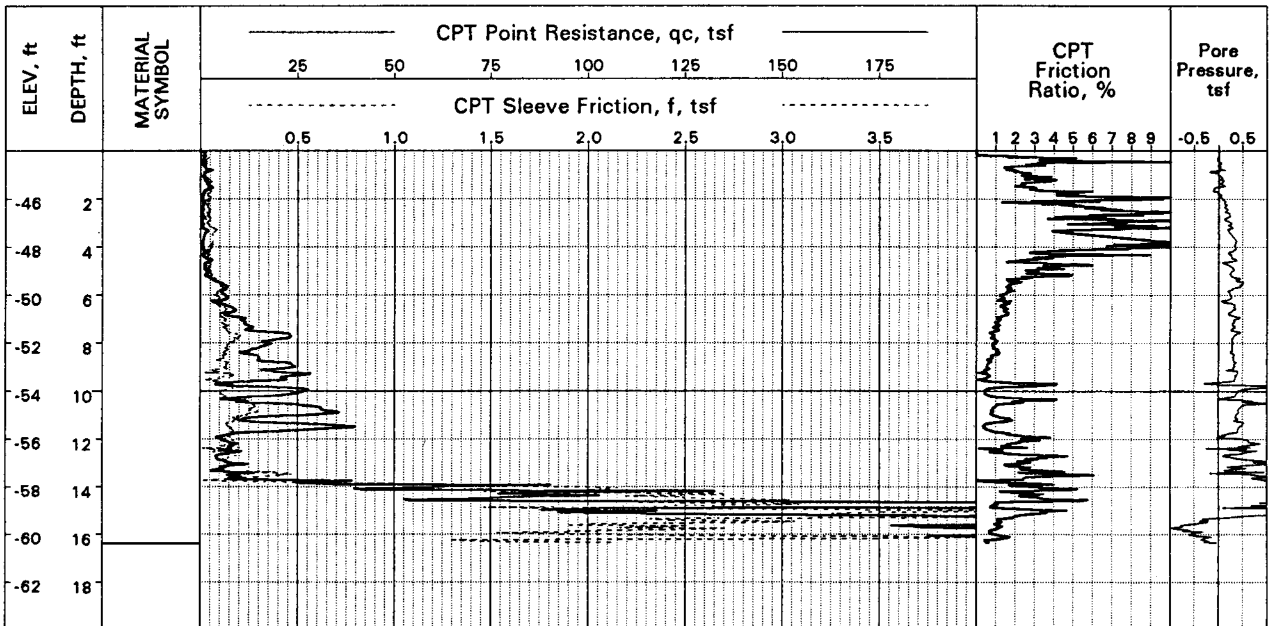
VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

COMPLETION DEPTH: 7.6 ft
DATE OF EXPLORATION: April 25, 1997

LOG OF CPT NO. CPT-90

UGIS ID: FD97C090

LOGS OF CPTs
POLA Channel Deepening
Port of Los Angeles



LOCATION: N 4,021,592 E 4,206,600
ELEVATION: -43.6 ft (re: MLLW; based on water depth of 45.5 ft and tide of 1.9 ft)

COMPLETION DEPTH: 16.4 ft
DATE OF EXPLORATION: April 25, 1997

VESSEL: M/V Ranger
TESTING METHOD: Seascout CPT
REVIEWED BY: GSResnick

LOG OF CPT NO. CPT-91

UGIS ID: FD97C091

LOGS OF CPTs
POLA Channel Deepening
Port of Los Angeles